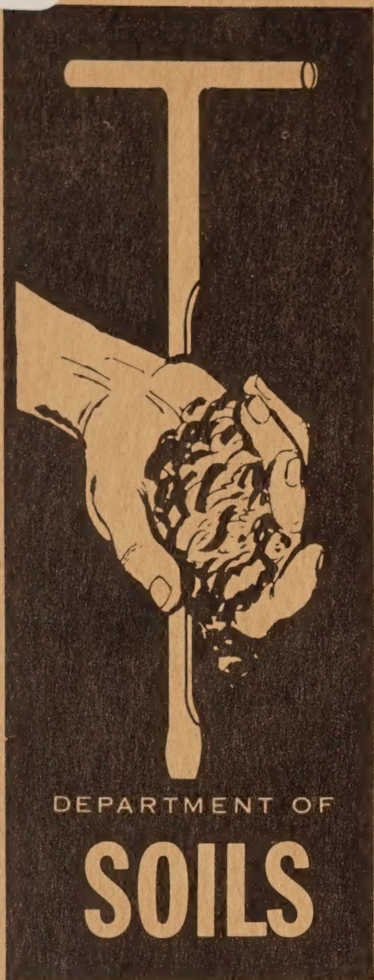

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Guides to Land Management in North Carolina

GUIDES TO LAND MANAGEMENT

IN

NORTH CAROLINA

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FOREWORD

One of the principal assets of Agriculture is land. Good land management is essential to successful farming. In selecting practices to follow on a given piece of land, there are a number of factors that should be considered.

In June of 1957, a four-day conference was held at North Carolina State College and invitation papers were presented on factors influencing land management. Authors of these papers included C. C. Abernathy, Louis Aull, W. V. Bartholomew, C. E. Bishop, H. J. Bragg, N. T. Coleman, J. C. Ferguson, E. F. Goldston, C. L. Hunt, E. J. Kamprath, G. C. Klingman, W. D. Lee, J. F. Lutz, R. J. McCracken, C. J. Nusbaum, J. E. Pollock, P. H. Reid, G. M. Renfro, J. N. Sasser, George L. Sherman, Clyde F. Smith, Forrest Steele, W. W. Stevens, S. L. Tisdale, C. H. M. van Bavel, Jan van Schilfgaarde, J. B. Watts, S. B. Weed, W. G. Woltz and W. W. Woodhouse, Jr. These papers served as a basis for the development of the material presented in this bulletin.

The purpose of this bulletin is to serve as a guide to agriculture leaders in North Carolina in respect to problems of land management. Of necessity, it cannot be so specific that it will cover all individual land problems. Basic principles are presented, however, which should be helpful with many of the land management problems encountered.

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GUIDES TO LAND MANAGEMENT IN NORTH CAROLINA

INTRODUCTION

Farmers and nonfarm businessmen depend to a great extent upon each other for the successful operation of their businesses. Farmers depend upon industry for supplies used in the production of farm products and for markets for their products. Industry, in turn, depends upon farmers for a source of farm products for processing and sale. Likewise, nonfarm businessmen depend upon farmers for markets for many of their products. About 24 per cent of the labor force in the United States is engaged in the production of farm supplies and in the marketing and distribution of farm commodities. Another 13 per cent of the labor force is engaged in the production of farm products.

Our population is growing rapidly and the markets for farm products are increasing accordingly. Many farmers compete for available markets, however, and markets buy from those who are able to serve them best.

The incomes of many North Carolina farm families are too low to support desirable levels of living. If our agriculture is to prosper, our farms must be organized to make the most efficient use of our agricultural resources. Farming must be based on science, and our farms must be operated in accordance with business principles.

One of the principal assets of agriculture is land. In order that farmers may enjoy a greater return from their land and more easily approach the return on investment realized from manufacturing, much greater consideration must be given to good land management. The land in North Carolina is classified into about 200 major soil series which

in turn are subdivided into various types and phases. Each of these series has its own particular characteristics in respect to depth and kind of profile, texture, mineralogical composition, physical and chemical properties. Scientific studies have been made to determine the effects of many of these characteristics upon the returns that may be expected from farming. Good land management requires that practices should be adopted which will give the most efficient use of the land, labor and capital resources on each particular farm.

It is the purpose of this bulletin to present in concise form the following:

(1) A discussion of the decisions to be made in evaluating land use adjustments.

(2) A discussion of the factors to be considered in a complete evaluation of land management decisions.

(3) Some guides to technically efficient land use in North Carolina.

ECONOMIC FACTORS IN LAND MANAGEMENT

Economic Factors and Land Management Decisions

As a decision maker and manager of a business, the farmer has the responsibility for (1) appraising the many alternative uses of his resources, (2) for deciding upon a plan which will be followed on his farm, and (3) for carrying out this plan. He must decide (1) what to produce, (2) how to produce each product, (3) how much of each product to produce, (4) when and where to buy the supplies that he uses, and (5) when and where to sell the products that he produces on his farm.

A farmer's labor, land and other capital resources are means of fulfilling his wants and those of his family. The level of living that

a farm family can afford depends upon the kinds and amount of land, labor and capital controlled by the farmer and upon the use made of each resource.

Virtually all farm products can be produced in North Carolina. Furthermore, most of these products will return some profit to farmers. If farmers are to receive a reasonable return, however, from the total investment in their farms, it is necessary that they produce those products which will yield the greatest net return from their total resources over a period of time. Farmers know that if they concentrate on the production of some commodities and produce these for sale, they can purchase other commodities and be better off than if they try to produce all products they consume.

In his efforts to fulfill his wants, a farmer is limited by many factors. Some of these are beyond his control, but he needs to understand them as they exist in making production decisions. That is, he must make the best decisions that he can, given the situations he faces. On the other hand, some conditions can be modified by the farmer, and he can increase his income by changing them. It is important, therefore, that the farmer know the characteristics of the resources which can be controlled by him and the effects of changing these characteristics upon the income that may be obtained from his farm.

<u>Capital, Labor and Land Resources</u>

One of the principal limitations on the amount of farm products that can be produced on farms in North Carolina is the amount of capital that farmers have with which to purchase or rent items used in production. Modern farming requires a large investment. Many

farmers in North Carolina, however, own very small amounts of assets and can borrow only a small amount of money with which to finance farm adjustments.

Another limitation on production is the amount and kind of labor in the farm family or the availability of labor for hire. The training and experience of the available labor supply are important considerations, especially in the production of commodities requiring a high degree of skill. The lack of a skilled labor force may be important in introducing new products.

The kind and amount of land controlled also are important considerations affecting the kinds and amounts of products that will be most profitable for a farmer to produce. There are wide variations in soil conditions from one farm to another as well as on a given farm. The income that will be received from a farm, therefore, will depend upon the use made of every acre of land. Good land management requires that each acre of land be put to the use for which it is best suited for sustained high production.

The best uses of land, labor and capital on a farm depend upon the amounts of each of these resources owned or controlled in relation to the amounts of the other resources. For example, a farmer who owns relatively small amounts of land and capital, but who has a large family will be inclined to produce commodities that use large amounts of labor and small amounts of land and capital per dollar value of product. Tobacco, cotton, vegetables and small fruits are among the commodities that tend to be produced on such farms. On the other hand, farmers with relatively large amounts of land and capital in relation to their labor tend to concentrate on the production of commodities that require a

small amount of labor and relatively large amounts of land and capital per dollar of product. The production of beef using the cow and calf plan is an example of such an enterprise.

Markets Available

Another factor that has an important bearing on production decisions is the availability of markets to the farmer. A farmer must determine what outlets are available to him and choose products that may be sold in these outlets. Modern markets require large volumes of standardized products. As an individual, a farmer produces such a small quantity that he usually has very little influence in determining whether a market outlet will be established in his particular locality. In cooperation with other farmers, however, production may be expanded to such an extent that it becomes profitable to develop new local market outlets.

Market conditions are constantly changing. The rate of increase in consumption is not the same for all farm products. Commodities which are expected to have large increases in consumption during the next 15 years include beef, pork, poultry, eggs, tomatoes, leafy green and yellow vegetables, fruits and possibly tobacco. Commodities expected to have relatively small increases in consumption include the food grains, potatoes, and dried beans. Profitable opportunities from expansion of production are likely to be greater in the case of commodities where consumption is expanding at a high rate.

Government Regulations and Allotments

Farmers, acting as a group, and society, acting through government, control to some extent the products which may be produced by individual farmers and the resources that may be used in production of particular

commodities. Government regulations change with time. These changes often have an important bearing upon the incomes of farm families, and it is necessary that farmers understand the manner in which their income possibilities are affected by these programs if they are to receive maximum benefit from them.

Produce Each Output at Minimum Cost for Maximum Profit

In spite of the large number of conditions that limit production decisions, each farmer still has the opportunity to produce many products on his farm, and he has many possible ways of producing each product. In choosing from among the many products that can be produced on his farm, the farmer is guided by the return that he expects to get from the use of his resources.

The net revenue to the farmer is the difference in what he receives from the sale of his products and what it costs him to produce them. For any given set of prices of farm products, therefore, the net revenue that the farmer receives depends upon the cost of production. In managing his farm, the farmer seeks to combine his land, labor, and capital in a way that gives him the products which he produces at minimum cost. Minimum cost production and maximum profit do not necessarily occur when yields per unit of land and other resources are greatest. In fact, under most conditions maximum yield per acre would not be consistent with maximum net farm revenue. The increased costs of obtaining unusually high yields may more than offset the income obtained from the increase in yields.

In the production of most commodities, one input can be replaced by another to some extent without changing production. For example, silage can be substituted for grain to some extent in the production

of milk without affecting the level of milk production. Under these conditions, silage should be substituted for grain until the milk is obtained at least cost. Least cost production is obtained only when it is impossible to reduce the cost of production by replacing some of one input with another without decreasing the level of production.

It is in the interest of the farmer to produce each commodity that he produces at least cost, given the situation on his farm. Even so, cost of production will vary from farm to farm depending upon the conditions that exist on the farms. Furthermore, in choosing a method of production, one should consider the long-term as well as the short-term effects. It may be less costly, and more profitable, in the short run to continuously produce row crops on land. But, over a long period, production and income may be greater if a rotation of row crops and sod crops is used. In choosing methods of production to be used, therefore, farmers should give consideration to the effects that each method is likely to have on costs of production and yields of product over a long time period on his farm.

Each farmer has many possible uses for his capital, land, and labor. A transfer of resources from one commodity (say corn) to another (milo) is profitable if the increase in income from one product (milo) exceeds the reduction in income from the other product (corn). As long as this condition exists, it will pay the farmer to shift uses of his resources, increasing production of some products and decreasing production of others.

In the above case, corn and milo require the same farm resources to a large extent; hence, they compete for resources. On the other hand, some products supplement or complement others in the use of

resources. Under these conditions, it is profitable to produce both products if it is profitable to produce either.

One way of deciding which farm products to produce is as follows: Determine how much of each resource will be required to produce a unit of each product considered for the farm. Estimate the cost of obtaining these resources. Then, estimate the income that might be expected from the sale of the product. The difference in the income that can be received from the sale of a product and the cost of the items used in producing it represents the net return the farmer will receive. When the net return has been estimated for each product considered by the farmer, he can then determine the maximum net return which can be produced with the available resources on his farm. He does this by comparing the effects of changes in the combination and volume of farm products on the net revenue to the farm family. The process is one of increasing the production of a commodity and determining whether the increase in income from the increase in that commodity is greater than the loss in income that must be taken in order to transfer the resources from other commodities to that commodity. When it is no longer possible to increase income by transferring resources from one product to another, the optimum combination of products has been obtained.

PHYSICAL AND BIOTIC FACTORS IN LAND MANAGEMENT

Soil As A Land Management Factor

Soil

Soil constitutes the largest investment in most farming operations. In order to obtain the greatest return from the soil, management practices should be geared to soil conditions and characteristics.

Definition

(Many definitions have been prepared to describe soil and it is difficult to select any one as best).

Soil is a naturally occurring body, three dimensional in nature, formed through the action of weathering processes on soil forming materials (rocks and minerals) under the influence of climate and biotic factors. Since the parent materials vary widely and since the effects of climate, age, topography and biotic factors are variable, soils are quite variable.

Profile

The soil profile is the vertical section from the surface of the ground to the underlying parent material (or rock). Its characteristics are the result of the many factors influencing the development of the soil. The soil profile is separated into horizons which usually are denoted by letter. The A horizon occurs at the ground surface and usually contains more organic matter than the other horizons. It is subjected to the various cultural practices utilized in farming operations and it is the horizon that will be eroded first by wind or water.

The B horizon is the subsoil and lies between the surface soil (A horizon) and the parent material (C horizon). It is the layer of accumulation and frequently contains the largest amounts of clay and iron compounds.

Importance of Classification

Classification of soils is very important in order to identify and associate significant characteristics of soils. For example, the thickness and characteristics of the horizons will determine the

amount of nutrient elements and water that will be available to plants. Strongly acid or compact subsoils may not permit plant roots to penetrate deeply into the soil. Restricting the roots to the surface horizon greatly reduces the volume of soil that could store moisture for plant use in dry periods.

Soils with similar characteristics, such as parent material, topography, thickness of horizons (depth of profile), presence of compact layers, texture and structure, may be grouped into a series. The soil series, in turn, may be divided into soil types and phases. The texture of the surface soil characterizes the soil type. A phase indicates a specific condition which is important in use and management. For example, in Cecil clay loam, sloping eroded phase, the "Cecil clay loam" denotes the type, "Cecil" is the series name; "sloping eroded" is the phase that indicates the surface horizon is not as deep as usually occurs for this soil type and is on sloping land. Each soil has its own management problems.

Soil Groups

North Carolina soils have been grouped in this bulletin (appendix) according to similarity of mineralogical, chemical and physical characteristics for use in selecting management practices.

North Carolina soils in general are acid in reaction and low in fertility. Many of the soils, particularly in the Piedmont and Mountains, are high in iron and aluminum. The high aluminum content of the acid subsoils presents a difficult problem in getting deep penetration of plant roots.

Land Classes*

Conditions of the land, such as slope, degree of erosion, depth of topsoil and drainage, greatly influence productivity and management requirements. As an aid in selection of management practices, the soil series frequently are grouped into capability classes, subclasses and units. Land capability classes denote magnitude of hazards and limitations; land capability subclasses refer to kinds of hazards and land capability units, which are a kind of management grouping for specific purposes.

There are eight land capability classes of which classes I through IV include lands suitable for cultivation, but classes V through VIII contain lands not suitable for continuous cultivation and are better adapted to pasture, woodland or wildlife uses. Each of the subclasses are designated by a letter which indicates the major kind of hazard. The letter "e" indicates an erosion problem, "w" a water problem and "s" droughtiness or low fertility. The capability unit is a division of the subclass and is designated by a number.

Climate in Land Management

Climate is one of the most important factors influencing crop production and, as such, must be considered in land management. Climate may be divided into two categories: macro-climate and micro-climate. The difference in the divisions is largely in the proximity of the earth's surface. Micro-climate is the "climate near the ground", but the macro-climate involves the atmosphere above a height of four

*Land capability tables, 1957. Published by S. C. S.

to six feet. The layer of air near the ground (micro-climate) in an area of vegetation is much different than the air above in the macro-climate zone. Important differences in micro-climate exist because of direction and degree of slope, kind of soil, nature of vegetation, wind protection, air drainage, light variation, and other conditions.

Macro-climatic Factors that Influence Land Management

1. Radiant energy - received from the sun. Incoming radiation is the source of light for photosynthesis. Under most conditions in North Carolina, the light is sufficient for maximum photosynthesis (about 2,500 foot candle illumination). Under some conditions of dense stands or where two crops are growing simultaneously, light may be deficient.

2. Effective precipitation. The amount, intensity and frequency of rainfall, storage capacity of the soil and the water losses that occur, (run-off, evaporation and drainage of excess water) especially during the growing season, determine the effectiveness of the precipitation.

The rainfall patterns vary across the state both in the total amount received and the frequency of rain. Of course, these patterns vary from one year to another. Nevertheless, precipitation exceeds evapo-transpiration (evapo-transpiration includes losses directly from the soil to the atmosphere and transpiration from plants) each year in North Carolina with an average excess of about 14 inches which results in stream flow to the ocean. Most of the excess precipitation falls during the winter and early spring months and leaching of soluble elements from the soil are most likely to occur during this period.

During the summer, evapo-transpiration generally exceeds precipitation and usually the amount of water entering the soil does not exceed the water storage capacity. Therefore, during the summer, when crops are making maximum growth, the loss of nutrient elements by leaching is at a minimum for most soil conditions. During the period when evaporation exceeds precipitation, droughts are most likely to occur. On many of the soils in North Carolina, there is likely to be a shortage of water for good plant growth unless sufficient rain to penetrate the soil at least 9 to 12 inches is received within a period of 10 to 15 days. Of course, soils with a high water table are less susceptible to drought.

The intensity or the rate at which the rainfall is received greatly influences the rate at which the water enters the soil, the depth of moisture penetration, the amount of runoff and erosion that will occur.

3. Air temperature. The temperature of the plant tissue greatly influences the metabolic activity and the rate of growth. Although the air temperature does not completely determine the temperature of the plant tissue, it greatly influences the growth rate and activity of the plant. No doubt, temperature of the air, more than any other factor, determines crops that can be grown within a region or during a given season. This is particularly true of the months when frosts are likely to occur.

Micro-climatic Factors in Land Management

1. Soil acts as a regulating reservoir for the heat from the sun. The greater the thermal conductivity of the soil, the more effective it is as a heat reservoir. Soils of high heat conductivity

(clays) have a more even temperature than soils of poor conductivity (sands). Sandy soils may attain a high temperature at the immediate surface but be cooler deeper in the soil. Color of the soil, mulches, crop residues, tillage procedures, direction of slope, air drainage, wind protection and nature of the vegetation also influence soil temperature. These differences in temperature may greatly influence germination of seed and the production of nitrate nitrogen in the soil.

2. Evaporation of water from soil and plants results in an important loss of moisture. In North Carolina, average monthly evaporation varies from a high of about 0.18 inches of water per day in June to about 0.02 inches per day in December. There is little variation in evaporation in the various areas of the state on a regional basis, but micro-climate may cause appreciable local variability.

Farming Under Variable Weather Conditions

In some instances the effects of climate may be minimized through management practices such as irrigation, drainage, cultural practices which permit working the soil under more adverse conditions, preapplication of fertilizers and the selection of kind of crops and varieties to grow. Crop diversification is also important in minimizing the affects of bad weather.

Biotic Factors in Land Management

Biotic factors in land management are concerned with those living things that influence crop production. These include the soil microorganisms (bacteria, fungi, actinomycetes, etc.), nematodes, earthworms, insects and plant roots. Most of these biotic factors directly or indirectly influence crop production. Often we emphasize the adverse affectsof biotic factors such as plant diseases, insects, nematodes,

and weeds. There are many instances, however, where biotic factors are very beneficial. Decomposition of plant and animal residues with the release of nutrient elements for plant growth is one of the most beneficial functions of micro-organisms. Humus is developed through this process and it greatly affects the physical and chemical properties of the soil including rate of water entry (infiltration), rate of water movement (permeability) and ability to hold nutrient elements.

Fixation of atmospheric nitrogen by symbiotic bacteria in the nodules on the roots of legumes, and by nonsymbiotic bacteria and the conversion of ammonia to nitrate are other examples of very important bacteriological processes that take place in the soil.

Insects are usually thought to be harmful in their depredation of plants; nevertheless, there are many functions that are very useful such as the pollination of flowers. Many insect also do much to control the population of injurious insects.

Much work and money is spent each year in the control of weeds. The deleterious effect of weeds is largely competition with crop plants for water, nutrient elements and light. There are situations where weeds are helpful by protecting the soil against erosion, by reducing runoff and by adding organic matter.

Competition among biotic factors in nature is great and each form of life tends to be held in balance by other forms of life as well as environmental conditions. It is difficult to control one factor by management practices without upsetting the balance and thereby influencing other factors. Fumigation of the soil to control nematodes, for example, not only reduces the nematode population by may reduce the population of useful micro-organisms, such as those responsible

for oxidizing ammonia to nitrate. Therefore, in selecting management practices that will control one biotic factor, careful thought should be given to harmful effects that might result with other biotic factors.

SELECTION AND APPLICATION OF MANAGEMENT PRACTICES

Water Control in Land Management

Water control refers to the maintenance of the correct amount of moisture in the root zone for the soil profile for desired plant growth.

Management of Irrigated Land

Good management of irrigated land involves maintenance of an adequate supply of soil moisture within the root zone of the soil profile for optimum plant growth. Water should be applied in the correct amounts as needed and in such manner as to avoid waste of water or damage to the land or crop.

Factors to Consider in Supplemental Irrigation

1. Kind of plants to be grown.

   Depth of roots, rooting habit (fibrous and tap roots), water tolerance and requirements for maximum growth must be considered.

2. Value of crop.

   Only crops of relatively high value will pay for the cost of irrigation under most farming conditions in North Carolina.

3. Thickness of stand.

   Thin stands are not desirable for irrigation due to low potential yield and high water loss per plant.

4. Depth of soil.

   Soil depth available for storage of water limits the quantity of water which can be stored in the soil for plant use.

5. Infiltration rate.

The rate at which water will enter the soil determines rate of application.

6. Soil permeability.

The measure of the rate of movement of air or water through the soil is determined by the soil characteristics of structure, texture, pore-size distribution, clay content and organic matter. This may be the limiting factor in determining rate of water application.

7. Disease and insect control.

Some diseases and certain types of insects may be more prevalent under irrigation. These must be controlled.

8. Probability of drought.

Over a period of years there is a pattern of rainfall which will indicate the frequency and duration of drought periods that are likely to occur.

9. Rate of application.

This must be based on the rate at which water can enter the soil, and in no case should water be applied at a rate in excess of the infiltration rate.

10. Tillage methods.

Breaking the surface crust will increase infiltration; puddling or packing of the surface will decrease infiltration. Ridge type cultivation may decrease infiltration, while flat cultivation will tend to favor infiltration.

11. Daily moisture use rates.

The quantity of water used by different plants at different stages

of maturity with respect to climatic conditions will determine frequency of irrigation.

12. Selection of equipment.

    The entire pumping and delivery system should be properly engineered and selected for maximum efficiency for the area to be irrigated.

13. Time required to irrigate a given area of land.

    This is important since labor and equipment should be used efficiently in timely irrigation of the area.

14. Level of management.

    High level of management, fertilization and land treatment are necessary if irrigation is to pay its biggest dividend.

15. When to irrigate.*

    Irrigate when the soil is below 50 per cent of field capacity, but before it reaches 25 per cent of field capacity. Permit the lower level of moisture to be reached only if irrigation equipment is adequate to irrigate the area rapidly.

    Most crops should not be kept growing at maximum rate throughout the season, but should be permitted to decrease vegetative growth and initiate fruiting and other maturing processes.

    Generally speaking, the sprinkler method is adaptable in all areas of the state. The use of surface methods, furrows and borders will be limited to the relatively flat lands of the Piedmont, Mountain bottom lands and middle and lower Coastal Plain. The nature of the

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*Irrigation recommendations for different soil groups and plants are contained in "Irrigation Guide", Part 8, Section 13, prepared by SCS in cooperation with N. C. Experimental Station and ARS.

soil profile which permits required land leveling and adequate sources of good water are important factors in determining if surface irrigation is practical and economical.

Drainage and Water Table Control

Drainage is the removal of excess water (or water which will be detrimental to the type of plants grown) from the surface or subsurface of the land. For best management of wet land, water table control must be integrated with drainage. Water control in respect to drainage refers to the maintaining of the correct amount of water in the soil above a water table. Completely installed drainage and water control systems are necessary for effective water management. Adequate outlets are needed for good drainage of excess water but adequate structures are also required for water table control.

Some Important Factors to Consider in Drainage and Water Control

1. Type of plants to be grown.

   The main purpose of drainage is to provide conditions in the soil in which plants can grow at a desired rate and utilize nutrients and water efficiently. The tolerance of plants to excess water, depth of root system and rooting characteristics of plants must be considered in determining the amount of drainage desired.

2. Soil Characteristics.

   Soil texture, structure, depth, porosity, bulk density, type of clay which influences shrinkage and swelling, permeability and biological factors influence the movement of water in the soil and will greatly influence the type of drainage system design.

3. Type of drainage

Types of drainage include surface and subsurface. Often a combination of both types is needed. Surface drainage is best accomplished by use of shallow open ditches; either V, W or trapezoidal ditches, bedding or land forming. Subsurface drainage may be accomplished by tile or open ditch drains.

4. Outlet.

Suitable outlets for all drainage must be provided. In very sandy or organic soil, extra precautions in constructing outlets should be taken.

5. Kind of drains.

To açcomplish the job of drainage, open ditch, tile or mole drains might be used. In some instances, two or three kinds of drains are used, but usually one kind of drainage is preferred over another. Usually it is not economical to use tile drainage in the loose sandy soils or the compact clay soils. In the majority of instances the kind of drains to be used is largely a matter of choice of the operator. Open ditches will drain any land as well as tile, and in addition will provide for surface drainage. On the other hand, tile will work satisfactorily for many conditions and has the added advantage of low maintenance and greater convenience in using fields and working the land. Open ditches are subject to filling and require large amounts of maintenance. They also present a serious weed problem and may harbor insects and plant disease pests.

6. Depth to lower the water table.

On soils with a high water table, the level of water may be lowered sufficiently to be detrimental to plant growth under certain

seasonal conditions. This is especially true on sands and organic soils. Excessive lowering of the water table can be prevented by use of water control structures. On very sandy soils, organic soils, and soils used for pasture, a water table lowered to 18 inches is considered adequate drainage. A lowering of the water level to 30 or 36 inches may be desirable on sandy loam or heavier soils where plants other than grasses or shallow rooted plants are to be grown. Control of the water table, or the ability to place the water level at any height in the soil, is ideal and an objective to be sought in water management. This points out the fact that as much emphasis should be placed on control of the water table as on the removal of excess water.

7. No single rate of draw down or lowering of the water table is desired for all plants and all soils. Under certain conditions, a draw down of 3 inches within 24 hours is adequate; in other conditions the draw down should be 12 inches or more in 24 hours. Plant maturity or kind of plants growing determine the needs for draw down rates and water table levels.

Deep drainage or lowering of water table to 24 inches or more is desirable if water control is not to be practiced for crops such as tobacco, cotton, alfalfa, peanuts and sweet potatoes. Stabilizing the water table at a selected depth is very important on mineral soils. <u>A fluctuating water table is highly detrimental</u>. Uncontrolled drainage will influence the water table to the depth of the system. In the absence of known techniques which are economical for controlling water level within many soils, a compromise system of draining land to a constant depth is usually

practiced. While such a system is not most efficient, it does offer some advantages and permits the growing of a variety of crops which is a great improvement over no drainage at all.

8. Depth and spacing of both ditch and tile are the determining factors in lowering the water table. Table 1 will serve as a useful guide for determining drainage and water control for different land capability units. (See land capability units attached as part of the appendix.)

9. All soils can be drained and the water table controlled, provided depth, space and type of drainage structures are properly designed. It may require very close spacing of tile or open ditches, which may not be economical at present in certain soils. On the other hand, very wide, shallow spacing of drains may be all that is needed. In the heavier soils, drainage ditches will need to be deep and closely spaced, while in the very sandy soils, drainage ditches should be shallow with relatively close spacing. In loamy sands, sandy loam and sandy clay loam, spacing will be wider and depth will vary between those in sands and on the compact clay soils. Seldom, if ever, will the water table need to be lowered to more than 36 inches and usually it should not be lowered to more than 24 to 31 inches on loamy sands for most crops.

   On sands and organic soils, the water level should not be lowered to more than 24 inches, and for most plants lowering the water table to 12 to 18 inches is all that is needed.

   Drainage should be considered in connection with controlling water in order to maximize its effectiveness in growing a given plant on a given soil condition. It is impractical at present and technically

Table 1. General drainage guide by land capability units.

LC Units	Spacing	Depth for profile drainage	Kind of drainage Open ditch or tile	Remarks
		Coastal Plain		
IIw-1C	Wide	Moderate	Either	
IIw-2C	Wide	Moderate	Either	
IIw-3C	Wide	Moderate	Either	
IIIw-IC	Medium	Shallow	Open ditch	Consider water table control
IIIw-2C	Close	Deep	Either	
(a)	Medium	Moderate	Either	Overflow may be a problem
IIIw-3C				
(b)	Close	Shallow	Open ditch	
IIIw-4C	Close	Deep	Either	
IVw-1C	Medium	Shallow	Open ditch	Water table control
IVw-2C	Close	Deep	Open ditch	Generally surface drains
IVw-3C	Medium	Shallow	Open ditch	Water table control
IVw-4C	Medium	Moderate	Open ditch	Overflow is a serious problem
		Piedmont and Mountains		
IIw-1M-1P	Protect only from frequent flooding			
IIw-2M-2P	Medium	Moderate	Either	
IIw-3M-3P	Medium	Moderate	Either	Some flooding, or spot drainage
IIIw-1M-1P	Wide	Moderate	Either	Overflow a serious problem
IIIw-2M-2P	Medium	Moderate	Either	Some flooding or spot drainage
IIIw-3M-3P	Close	Deep	Open ditch	
IVw-1M-1P	Wide	Moderate	Either	Overflow a serious problem
IVw-2M-2P	Close	Deep	Open ditch	May flood

Spacing

Wide spacing - generally over 150 ft.
Medium spacing - generally over 100 ft.
Close spacing - generally over 50 ft.

Depth

Deep Depth - generally about 5 ft.
Moderate depth - generally about 3.0 ft.
Shallow depth - generally about 2.0 ft.

inaccurate to develop a drainage formula which will hold for all soils and plant variations.

Saline and Alkali Soils: Reclamation and Management

A saline soil condition is an accumulation of soluble salts to such an extent that plant growth is reduced or stopped. Severe wind storms may cause tidewater areas to be covered with salty water from the ocean or sounds. Salt accumulations in soils can result from seepage into soils from drainage ditches in which salt water has "backed up." Water for irrigation may contain a sufficient amount of soluble salts to cause a saline condition if the salts accumulate in some area of the soil profile such as the immediate surface. Raising the water table may also bring soluble salts to the surface of the ground where elevation is only a few feet above sea level. In North Carolina, one of the most common saline conditions in a localized zone in the soil may be caused by poor placement of fertilizer. For example, the soluble nitrogen and potassium salts may reduce growth or kill young seedlings if placed with the seed or seedling.

An alkali soil has either so high a degree of alkalinity (pH 8.5 or above) or so high a percentage of exchangeable sodium (15 per cent or higher) or both, that growth of most crop plants is reduced. The exchangeable sodium when present in sufficiently large quantities causes the soil to run together when wet (puddle) and become very hard when dry. Alkali soils usually have their beginning from a saline condition in which the soluble salts are predominately sodium.

Diagnosis

Laboratory tests (made by the Soil Testing Division in Raleigh) can quickly diagnose these special soil conditions. The biggest problem

is getting a representative sample from the soil layer that is affected. Soluble salts usually accumulate near the ground surface, especially in dry periods. Samples should be taken of the first inch of soil and then in three inch intervals to the depth which may be affected (usually not over 12 to 15 inches deep.)

However, sodium or alkali soil conditions may exist any place in the soil profile and it may be necessary to dig a pit to find the problem layer. Samples of the soil taken by four to six inch intervals is usually sufficient.

Reclamation

Good drainage through the soil profile is the first requirement in reclaiming saline soil conditions. To reclaim a saline soil, drain and wash the soluble salts out of the soil profile to a depth of at least three feet.

If the salts are predominately sodium, such as usually found in ocean water, then drainage may result in the creation of a sodium soil (alkali). To avoid this, the addition of gypsum at the rate of one or two tons per acre is necessary. The gypsum gives no benefit in overcoming the salty condition. It is added to prevent the formation of a sodium condition. In some instances, the salts causing the saline condition contain sufficient calcium and magnesium to assure a base saturation with these two elements and all that is needed is drainage.

To improve existing alkali soil conditions, the sodium present must be replaced with calcium. Gypsum (calcium sulfate) is the best source of calcium for this purpose (unless the soil is calcareous). The rate of application of gypsum is related to the amount of clay and organic matter present. On sandy soils, low in organic matter, about one ton

per acre should be sufficient. On finer textured soils or those high in organic matter, about three tons per acre will be necessary.

Adequate drainage for the crop to be grown is a necessity for reclaiming either saline or sodium soil conditions and should be the first step to consider.

A temporary solution to saline soil conditions may be achieved by growing the more salt tolerant crops. Grasses and legumes, in general, are the most tolerant crops of saline conditions. Potatoes, beans, and similar crops are the least tolerant. Deep plowing to bury the salts may help for a sufficient length of time to establish a good stand of fairly tolerant crops like fescue.

Erosion Control in Land Management

Erosion means the wearing away and removal of soil by natural forces, usually wind and water followed by deposition. Management can alter the erodibility of soil by modifying aggregation, pore space, bulk density and compactness. Proper land management, which will control or alter erosion to the point of allowable rates, is essential.

Erosion control in land management will be discussed under two main headings: (I) water erosion; (II) wind erosion.

I. Water Erosion: The erosion process consists of three principal sequential steps. First, the soil particles are torn loose or detached from the soil mass; second, the soil material is transported; third, the soil material is deposited. Falling raindrops and flowing water are the two principal agents of water erosion. The energy of the falling raindrops serves to detach the soil particles from the soil mass. The energy of the flowing water is applied approximately parallel to the earth's surface and is

expended in developing rills, gullies and transportation of soil materials.

The energy of falling raindrops frequently is many times that of flowing runoff water. There is a direct relation between the energy expended by the falling raindrops and the resulting soil loss for a given soil. Erosion control in land management must be designed to do two things: first, break the force of falling raindrops and second, retard and obstruct the force of the flowing runoff water.

(a) Kinds of Erosion

The kinds of erosion are: (1) gully erosion, where runoff concentrates in sufficient volume or velocity to cut deep incisions (gullies) in the land surface; (2) sheet erosion, where there is more or less even removal of soil in thin layers over entire segments of sloping land.

Removal of nutrient elements from the soil and surface puddling or crusting are important parts of the erosion process. As soil is washed away, valuable nutrient elements are lost. Puddling, which is caused by the beating action of the raindrops on exposed soil, tends to break down the structure and forms a tight layer at the surface. All of the kinds of erosion may occur on any slope, even including the flat coastal plain soils.

(b) Factors which Influence Erosion

Rainfall, slope, soil characteristics and cover are the four primary factors which influence erosion. The amount and kind of erosion is closely related to the intensity of the

rainfall. The greater the intensity, the greater the erosion for a given condition.

Erosion rates increase markedly with steepness of slope, and soils on long slopes erode faster than soils on short slopes. Erosion control practices, such as contour tillage, terracing and strip cropping, break up long slopes into shorter ones and thereby reduce erosion damage. Soil characteristics that affect the erodibility of the soil are primarily texture, structure, organic matter content and chemical composition. Some soil characteristics that influence erodibility can be modified by management, while others cannot. Texture, for example, is not subject to change except as erosion removes surface soil, exposing layers of different texture which may be more subject to erosion than the surface.

Structure is subject to change by management, and is of importance in determining the erodibility of a soil. Aggregation and porosity, which are also important soil characteristics, can be changed greatly by management. They affect infiltration and permeability, and hence runoff as well as detachability and transportability of the soil particles.

The quantity and kind of organic matter contained in the soil is important in respect to erodibility, mainly because of its effect on structure. The most important physical effect of the organic fraction of the soil is increasing water permeability of the soil.

The chemical composition of the soil, particularly of the colloidal fraction, affects erodibility directly through its effect on physical properties and indirectly by the influence on the growth of plants.

(c) Effects of Erosion

Erosion results in lowered infiltration, increased runoff, reduction of organic matter, destruction of soil structure, reduced yields, clogged stream channels, damaged highways, filled reservoirs, more frequent flooding, destroyed crops and damaged property.

Erosion often results in lowered yields, as it exposes successive layers of less productive soil. It does not stop at the stage of topsoil removal; on the contrary, erosion usually speeds up at this stage.

There is also a very close relationship between stands of crops and degree of erosion; and between winter killing due to frost damage or heaving and degree of erosion. As the degree of erosion increases, difficulty in obtaining stands of crops increases. The amount of frost damage and heaving also increases.

Although the productivity of erosion-exposed subsoil can be raised materially through the use of fertilizer, manure and rotations, it is generally agreed it is more economical and practical to maintain the topsoil.

(d) Management Practices to Control Erosion

In a proper land management program, land should be used within its capability and treated according to its needs through

the use of adapted conservation measures.

Practices such as the use of close-growing crops, crop rotations, strip rotations, mulching, contour tillage and terraces, have proven highly effective in controlling water erosion on cropland when used in needed combination for the land capability class.

(1) Vegetative

(1a) Cropping systems

Cropping systems influence runoff and soil loss. Studies show that when row crops are grown in rotation with sod crops, the soil and water losses are less than when row crops are grown continuously. To be most effective, cropping systems must be selected to meet the needs of the land capability class. The goal is to achieve harmony between the farmer's needs for cultivated crops and the needs of the land for protection.

In addition to reducing soil and water losses, cropping systems are important in land management in helping to maintain and sometimes to increase yields. Research results show that grasses and legumes grown in rotations for soil protection may <u>also</u> affect yields of other crops in the rotations favorably when used in combination with other good soil management practices.

Close growing crops, usually perennials, are an integral part of an effective soil conserving cropping.

system. A cover of vegetation is the first defense against runoff and erosion. Some Guides to Cropping Systems in North Carolina, published by the N. C. Agricultural Experiment Station in cooperation with USDA Soil Conservation Service, includes basic principles and suggests cropping systems for each land capability unit in the state.

(1b) Strip Cropping

Contour strip cropping is a very effective and practical means of protecting land from erosion. The practice of strip cropping, in effect, divides a long slope into a series of shorter ones. Strips of close-growing crops planted across the slope will not only decrease runoff and soil from the area they occupy, but will act to desilt the water flowing over them from cultivated parts of the field above. Strip cropping can materially assist in control of erosion and maintenance of the soil in a good state of production on Class IIe, IIIe and much IVe, field stripping may have to be substituted for contour strips. On many of the IVe lands the soil is usually too shallow, the slopes too steep, or land too severly eroded for frequent cultivated crops. On this class of land, long rotations with a maximum of sod crops, hay or pasture, is best suited. Strip cropping is an effective way to renew hay or pasture stands on Class IVe land without exposing the entire slope.

On sloping land, contour cultivation and terraces alone, or strip cropping alone, may not be adequate to control erosion, but contour strip rotation with terraces is often considered the ideal combination where row crops are to be grown to any appreciable extent.

(1c) Protecting the Surface of the Land

Mulching with organic residues reduces the starting of erosion. Many other measures are attempts at control after the erosion process has started. The function of organic residues is to intercept and absorb the force of falling raindrops. They also reduce evaporation. Only a relatively thin layer of mulch is needed. For example, as little as two tons of straw on the surface has been found to be very effective for many soil conditions.

(1d) Deep-Rooted Crops

Deep-rooted crops may alter or influence soil structure and soil permeability on certain soils. Most of our highly erodible soils have a low permeability rate and our least erodible soils have a high permeability. Any change which could be brought about by types of plants or crops to increase the permeability of the soils with low permeability may decrease soil loss and runoff and result in conservation of soil and water.

Deep-rooted plants such as kudzu, alfalfa, sericea, tall fescue grass and bahiagrass tend to open up tight soils where physical factors rather than chemical limit root penetration. Deep-root penetration improves aeration and water movement rates and other conditions for plant growth. These soils, so modified, will take in more water which reduces runoff and soil loss and at the same time aids in increased productivity. Both surface and subsoils have been favorably changed by cropping systems which included deep-rooted plants. A tight soil which can be opened up to greater depths by deep-rooted plants may benefit certain crops which follow, since a greater profile depth has been brought into functioning in growing the plant.

(1e) Reducing Soil Acidity

Reducing soil acidity with adequate liming and the addition of necessary fertilizers will increase plant growth for production of necessary residues which includes the roots. This is a key point in controlling erosion.

(2) Mechanical

(2a) Waterways

A sod waterway or meadow strip is a sodded depression (natural or constructed) designed to collect runoff water from contour rows, terraces and diversions and

carry it to a stabilized grade. The importance of waterways in the control of runoff water from cultivated land cannot be overemphasized.

Natural depressions are usually the best locations for waterways. They require a minimum of shaping, and the soil is usually favorable for good growth of desirable vegetation. A broad u- or w-shape is best to keep water from concentrating at any point. Deadfurrows or depression between the adjoining fields and waterways must be avoided.

Waterways, where possible, should be of sufficient size to carry the maximum expected runoff. Usually they should be large enough for mowing.

To establish a vigorous vegetative cover as soon as possible, the seed and fertilizer rates in most instances should be about double those used on pasture or hay fields.

(2b) Contour Tillage

Contour tillage is a practice that is needed on all cropland with appreciable slope. It is one of the simpler practices for reducing soil and water loss. Contour tillage is effective in proportion to size of ridges made by tillage implements. Results from research show a reduction of as much as 50 per cent in soil loss and 20 per cent in runoff and land planted to corn on the contour, as compared to up-and-down the hill rows. Its effect on yields is

most noticeable in years when rainfall is scarce during the growing season.

Contour tillage alone may protect the soil on land capability Class IIe and IIs land during the milder rains, but is of less benefit when the storms are intense.

As the per cent of slope or length increases, the degree of effectiveness of contour tillage decreases. Likewise, protection is not sufficient on soils that are severely eroded, or clay soils of low permeability. On land capability subclass IIIe and IVe, additional practices such as terracing or strip cropping are needed.

(2c) Terracing

A terrace is a combination of ridge and channel built across the slope on a nonerosive grade to control surface water. Deep sands, stony fields or soils underlain with rock at shallow depths are unsatisfactory for terracing due to cost of construction and difficulty of maintenance. Terraces should be laid out so that a practical, tillable row pattern can be worked. They should be built so that they are easily cultivated with conventional machinery. The more nearly two terraces parallel each other, the easier it is to farm the space between them.

Parallel terraces can be placed on uniformly sloping land (capability subclass e land). Short rows are

eliminated and the field prepared for precision mechanized farming on the contour. With parallel terracing, a stabilized outlet must be available or provided for the runoff water before the terrace is built. Conventional terraces that have a continuous controlled grade from the crest to the outlet have been most satisfactory.

Terraces are an important practice on most of the land capability subclass e land. All soil and slopes cannot be terraced satisfactorily. Undulating, knobby and warped slopes should be considered "non-terraceable" on any class. Terraces may not be feasible on some IVe land and are not recommended on slopes steeper than 8 to 12 per cent. On shallow soils or those with compact, heavy or plastic subsoils, consideration should be given to land use or cropping systems that will protect the land without terraces.

(2d) Diversions

A diversion is an individually designed channel constructed across the slope for the purpose of intercepting surface runoff and conducting it to a safe outlet. It is similar to a regular terrace in shape, but is usually larger.

Diversions are used to:

(1) Protect low-lying fields or installations from hillside runoff; (2) Divert water out of active gullies; (3) Regulate amount of surface

entering a farm pond; (4) Break up the concentration of water on long slopes; (5) Permit the use when regular field terraces cannot be used.

II. <u>Wind Erosion</u>: Wind erosion damages the area from which the soil particles are removed and the area on which they are deposited. Sandy soils hold less water and have larger pores than finer textured soils. Thereby, they dry more rapidly and are more subject to blowing. About 80 per cent of wind erosion in North Carolina occurs in the "Sandhills" and Upper Coastal Plain sections. The soils most subject to wind erosion are the sands and loamy sands in the land capability subclass s. However, under certain conditions all soils are subject to some wind erosion. A thoroughly pulverized dry soil is most severely damaged, while a soil covered with a thick, growing sod is least susceptible. Wind damages soil in several ways. It removes first the fine soil particles and fine organic matter. The removal of the fine particles tends to make the soil coarser, less fertile and less productive. This process, if continued over several years, can materially change the texture. Many factors are associated with the erosion of soil by wind. They can be grouped under three major categories - climate, soil and vegetative cover. Conditions most favorable for wind erosion are high velocity winds and dry soils when the land has just been prepared for planting. Thick, growing vegetation is the most effective control measure. Dead

plant residue varies greatly in its ability to reduce the force of wind at the soil surface. Standing stubble is more effective than plowed or disked residue.

The damage from wind erosion extends beyond soil and crops. Highway and drainage ditches are often partially or completely filled with wind-transported materials requiring expensive "clean out" operations. Machinery is also damaged by sand and dust.

(a) Methods of Control

Wind erosion control measures may be divided into two groups, permanent and temporary. The permanent group includes trees, shrubs and perennial plants for hay or pasture, while the temporary group includes plants and plant residue use in the cropping system on cropland, and mechanical measures such as contour tillage, ripping, listing and other methods of rough land preparation. Crop land may require a number of protective measures. The kind and extent of these measures will depend on the severity of the hazards.

(1) Windbreaks

Tree windbreaks planted perpendicular to the prevailing winds are needed in large open areas subject to severe wind damage. Pines, planted in two, three or four rows, supplemented with cedar or shrubs planted of the windward side are adequate. Thick growing shrubs such as shrub lespedeza and privet planted on the windward side instead of

cedar increase the effectiveness of windbreaks. Distances between windbreaks vary from 300 to 800 feet depending on conditions being treated and type of trees used. Under North Carolina conditions, 400 to 600 feet seems most desirable. The distances between windbreaks may be increased when other good erosion control measures are carried out on the cropland between windbreaks.

(2) Perennial and Rotated Strips

Perennial and rotated strips are effective measures in controlling both wind and water erosion. Some of the good perennial plants are sericea lespedeza, shrub lespedeza, kudzu and multiflora rose. The arrangement of the crops should be in strips across the prevailing winds on the nearly level land and on the approximate contour on sloping land.

The cropping system should include close growing vegetation at the time of greatest wind action for maximum control. The crops should also provide large amounts of plant residue. Large fields should not be planted entirely to cultivated crops; neither should all the field be prepared for planting at one time. Close growing crops such as small grain-crotalaria and row crops in equal-width alternate strips are desirable.

The seeding of winter cover crops between row crops reduces wind damage. Many tobacco growers often

leave the 5th or 9th row for use as a truck row while harvesting tobacco. These truck rows left in growing cover crops when the land is prepared for tobacco will reduce wind damage. Melons may be planted by preparing a row a few feet wide and leaving remainder of row middle in growing cover which can be destroyed as crops are cultivated.

(3) Management of Residue

Properly managed live and dead plant residues are also effective in reducing wind erosion. Plant residues should be left on the land surface as much as possible during the windy period. Final land preparation should be delayed as long as practical before planting the succeeding clean cultivated crop.

Methods should be used that tend to leave plant residue on a rough ground surface but at the same time leave it in such condition that a good stand and growth of the cultivated crop can be obtained.

(4) Mechanical Methods

Terraces, bedding, or listing, deep plowing, ripping, rough land preparation are mechanical means of reducing wind erosion, but are at best temporary and emergency practices and less effective than vegetation. Excessive working of the soil which results in pulverizing the surface (dust mulch) greatly increases the susceptibility to wind erosion.

III. Crop Residue Management

Crop residue is that portion of the plant which remains after the crop has been harvested, including both tops and roots. However, for this discussion, the definition will be broadened to include those crops that are planted for soil improvement and the conservation of soil and water.

(a) Factors to Consider in Utilizing Crop Residues

(1) Benefits

Vegetal cover, living or dead, in the soil or on the surface, offers an efficient method for reducing soil and water losses on cultivated land. Regular incorporation of crop residue into the soil helps to: improve soil structure, maintain organic matter, improve tilth, keep desirable microbiological balance, reduce evaporation, prevent soil surface from maximum sustained production, aid in control of some diseases and permit rapid movement of water into and through the soil.

(2) Amount Produced by Various Plants

Crops such as peanuts, tobacco, truck crops and annual legumes and grasses cut for hay on an average produce from one-half to two tons of dry residue per acre. Other crops like corn, small grain, annual lespedeza, cotton and some cover crops, produce from one to four tons of dry residue per acre. Perennials, such as sericea lespedeza, kudzu, Bermuda, Bahia, Orchard and tall fescue

grass produce up to 12 tons of dry residue per acre.

(3) Decomposition Rate

This depends on kind, stage of maturity and age of plant. Young succulent plants decompose more readily than mature fibrous plants that are higher in lignin content.

(4) Chemical Composition

Crop residues contain varying amounts of plant nutrients, depending upon the crop and fertilization. The nitrogen content of most mature crop residues except legumes is low. Small grain straw, perennial grass, cotton and tobacco stalks normally contain less than one per cent of nitrogen. Many residues are low in phosphorus and relatively high in potassium. Young plants are much higher in per cent nitrogen than mature plants and the rate of release of nitrogen from the residue is faster.

(5) When to Work Sod

This depends upon the quantity, quality, and desired placement of residue in the soil. In all cases, prepare far enough in advance of planting date to assure a good seedbed. Plant residues turned under may result in the soil being a little more open and the soil has a tendency to dry out more rapidly.

(6) Placement

Residue is more effective in reducing runoff and soil loss by wind and water erosion when kept on the surface of the soil than when turned under. It has its greatest influence on soil physical properties of the plow layer when incorporated into the soil. The rate of decomposition is most rapid when residue is plowed into the soil. In leaving residues on the surface, insect and plant disease problems may be encountered.

(7) Equipment Needed

Conventional implements usually found on most North Carolina farms will do a satisfactory job in handling residues. Simple adaptations and adjustments may be necessary with some residues and soil conditions.

(8) When and How to Prepare Sod Land

Prepare for enough in advance of planting to assure a good seed bed. Distribute residue through the plow area and leave some on the surface.

1.1 Planting without prior land preparation.*

(1a) Corn in small grain cover crops, soybean stubble and after peanuts.

(1b) Corn and soybeans (for silage) in small grain stubble after combining.

*Mulch Farming to Conserve Soil and Water - SCS Service Bulletin.

(1c) Soybeans, cowpeas, grain sorghum and millet in small grain stubble after combining.

2.1 Handling Grass-Based Rotations.

Mature perennial grass sods should be partially ripped or cut apart with conventional farming implements before they are moved from their growing position. Once residue is turned or otherwise torn loose from an anchored position, the more difficult it becomes to cut it into small pieces. Increased quantity and quality of many crops produced following a perennial grass sod will generally compensate for the additional expenses incurred in preparing a satisfactory seedbed. It is expensive and time consuming to prepare land and manage grass sods in a cropping system, but the benefits usually outweigh the disadvantages.

Soil Fertility Management

Soil fertility includes the status of the 13 nutrient elements in the soil that are now recognized as essential for plant growth plus the capacity of the soil to supply and transmit these elements to the plant over a period of time. The 13 elements include: (1) Primary elements - nitrogen, phosphorus and potassium; (2) Secondary elements - calcium, magnesium and sulfur; (3) Minor or trace elements - manganese, iron, copper, zinc, boron, molybdenum and chlorine.

Objectives in soil fertility management:

(1) To manage the soil in such a manner that it will release adequate amounts of nutrient elements during the growing period for the desired yields.

(2) To avoid losses of nutrient elements through:

   (a) Leaching downward through the soil by water.

   (b) Excess uptake of the elements by plants.

   (c) Fixation by the soil into forms only slightly available to plants.

(3) To overcome nutrient deficiencies and acidity in order that plant roots may utilize the maximum volume of soil.

Practices in soil fertility management:

Soil testing: The first step in soil fertility management is to gain as much information about the soil characteristics with respect to nutrient supply and release as possible. Therefore, a good soil test should be made of all fields on the farm.

A representative sample should be taken; otherwise, the test may give erroneous information. A composite sample should consist of 15 to 20 cores or borings regardless of the size of area that is being sampled (usually the area should not exceed five to ten acres in size). The depth to sample the soil is determined by the placement that will be made of the soil amendments. Lime and phosphate do not move more than three to six inches in most soils. Therefore, plow depth is usually the depth of sampling. Where lime or phosphate will be broadcast on the surface of the ground, as on a pasture or lawn, then sample only the surface two or three inches.

After taking the sample, make an accurate record of where the sample was taken, fill out the information sheets and send to the Soil Testing Division, N. C. Department of Agriculture in Raleigh, for a free analysis.

1. Primary Elements

Nitrogen, phosphorus (phosphate) and potassium (potash) -- These three elements are used in relatively large quantities by plants and were the first to be discovered as being essential for plant growth. The State Law requires that the percentage of these elements in a fertilizer be shown on the bag, and be expressed as total nitrogen (N), phosphate (P_2O_5), and potash (K_2O).

a. Nitrogen enters the plant roots in the forms of ammonium ions (NH_4) or nitrate ions (NO_3). Other forms of nitrogen, such as protein materials found in plant or animal residues (example - cotton seed meal or blood meal) or urea, must be converted to the ammonium and nitrate forms to be taken up by plants.

Organic materials decompose rapidly under warm moist conditions. Under the climatic conditions in North Carolina, decomposition takes place the year around, but probably is most rapid in the spring and fall. During the growing season, under most North Carolina conditions, cotton seed meal, blood meal and similar materials will decompose appreciably within a period of three weeks.

Conversion of Urea:

Urea is rapidly converted to ammonia soon after coming in contact with the soil or plant materials. Usually, the conversion will take place within a matter of hours or, at the most, within a few days.

Conversion of Ammonia:

Ammonia is converted to nitrate by bacteria in the soil. The rate

at which this is done depends upon several factors including the amount of ammonia present, soil temperature, moisture and acidity. In most North Carolina soils, which have not been fumigated, much of the conversion of ammonium to nitrate will take place within two to three weeks.

Leaching of Nitrate:

The greatest loss of nitrogen from the soil is from crop removal and leaching by excess rain or irrigation. Leaching losses are directly related to the kind of soil involved. The success of early application of nitrogen fertilizers for corn, is directly related to the soil type. Sandy soils do not hold much moisture and losses of nitrogen will occur regardless of the form in which the nitrogen has been applied. (Ammonium, urea and other sources of nitrogen are converted to nitrate which is leached.) The finer-textured soils hold more water per foot of depth and leaching losses, even of the nitrate form of nitrogen, may not be excessive. Greatest leaching occurs when the precipitation exceeds evapotranspiration. (In North Carolina this is most likely to occur in the spring of the year.)

Uptake of Nitrogen by Plants:

Most plants will take up both nitrate and ammonium forms of nitrogen but some plants absorb one more than the other. Tobacco responds most to nitrate nitrogen and, if the soil has been fumigated for nematodes or other pest control, it is advisable to use nitrogen fertilizer containing at least 25 per cent of the nitrogen in the nitrate form.

b. Phosphorus is deficient in most of the virgin soils in North Carolina. Since phosphorus moves but little in the soil, many of the

fields in the state have been built up on this element through heavy fertilization. This is particularly true where high return per acre crops such as tobacco have been grown.

Phosphate when applied as superphosphate is in a relatively available form for plants. The superphosphate may be changed to other forms in the soil (iron and aluminum phosphates), which are relatively unavailable, and the phosphate is said to be "fixed." Reddish soils in the Piedmont and Mountains generally are high fixers of phosphate. The sandier soils of the Coastal Plains, such as the Norfolk or Lakeland, fix very little phosphate.

Fertilizer placement is very important on soils that fix phosphate. Band application is the most effective method, especially on row crops. Broadcasting the phosphate fertilizers is most efficient on low fixing soils like the Norfolk.

Rock phosphate has not been found to be very efficient on most North Carolina soils due to the low total acidity present.

c. Potassium is deficient in most North Carolina soils, especially in the Coastal Plains.

It is difficult to increase the potassium content of soils because of (1) leaching, (2) excessive uptake (luxury consumption) of potassium by plants if it is available and (3) "fixation" of potassium by the soil into forms less available.

The chloride, sulfate, metaphosphate and nitrate salts of potassium will leach from the soil to about the same degree.

Soils that are adequately limed do not lose potassium by leaching as readily as acid soils.

2. Secondary Elements:

a. Calcium and magnesium occur in most fertilizers but the cheapest and best source is in dolomitic limestone. Almost all soils in North Carolina that are deficient in calcium are also deficient in magnesium. Therefore, when a soil needs these elements, dolomitic limestone is recommended.

b. Sulfur is needed in almost the same quantity by plants as phosphorus. In applying superphosphate to the soil, sulfur is also applied in the form of gypsum. Sulfur is also returned to the soil from smoke, etc. in the atmosphere by rainfall. Therefore, sulfur deficiency has not been a problem in this state.

Sulfur deficiency is most likely to occur on sandy soils that are very low in organic matter. Where a sulfur deficiency occurs only about 10 pounds of elemental sulfur per acre is needed to correct the condition. Cotton and ladino clover are good indicator crops for sulfur deficiency.

3. Trace or Minor Elements:

Trace elements are needed in only small quantities by plants, and most North Carolina soils can supply a sufficient quantity of these elements. There are some conditions, however, where additional trace elements are needed for good plant growth. The role of the trace elements in plants appears to be connected with the enzymes and enzymatic reactions. Only a very small amount of the trace element is needed to "trigger" the reaction.

The total amount of the trace element present is no guide to the amount a plant takes up from the soil. The assimilation is dependent upon several factors including:

(1) Soil Acidity - As the soil becomes more acid, elements like manganese, iron and zinc become more soluble, and as the acidity is

reduced, they become less soluble. A soil at pH 7.0 or above may be deficient in available iron and manganese, particularly for some plants like camellias, azaleas and roses. The same soil at pH 4.0 may contain a toxic amount of these elements. Molybdenum deficiency is not found in North Carolina where the soils have been adequately limed but it has been found on acid soils.

(2) Organic matter in the soil combines with many of the heavier metals including maganese and copper. Copper defınciency is most likely to occur on the high organic matter soils that are poorly drained in the Coastal Plains.

(3) Drainage and aeration of the soil determines the state of oxidation of elements like iron and manganese which influences their availability.

(4) Presence of other minor elements and nonessential elements - the availability of one trace element is greatly influenced by the amount of other trace elements in a soluble form that are present. For example, the amount of iron that is available for plant growth is influenced by the amount of soluble zinc, copper, manganese and molybdenum present and vice versa. Aluminum also greatly influences assimilation of trace elements.

Soil tests can determine the amount of a trace element present but interpretation of the results in view of the factors presented above makes the tests of little value. A manganese test which has some value has been developed at State College. It can be required when submitting a soil sample to the Soil Testing Division for analysis. Soil acidity, amount of organic matter and drainage are the best guides to trace element deficiencies.

Commercial Fertilizers

North Carolina farmers are purchasing about 1.5 million tons of commercial fertilizers a year. This means an expenditure of over 50 million dollars. In order to get the greatest return from this investment, the farmer should understand the difference in fertilizers and which will be best for his land and crops that he wishes to grow.

Fertilizer Laws: The North Carolina law requires that the percentage of primary elements contained in a fertilizer shall be guaranteed and shall appear on the bag. The percentage of these elements constitutes the fertilizer grade. The first figure always refers to per cent nitrogen (N), the second is per cent available phosphate (P_2O_5) and the third is per cent available potash (K_2O). For example, a 4-8-12 fertilizer contains 4 per cent nitrogen, 8 per cent available phosphate (P_2O_5) and 10 per cent available potash (K_2O).

The other essential elements (secondary and trace) may be shown on the bag also, but if they are listed, the percentage must be guaranteed and are subject to inspection by the State Chemist.

Recommendations: Only a portion (usually less than half) of the fertilizer applied to soils is taken up by plants in any one year. Part is lost by leaching (nitrogen and potash) and part reacts with the soil. The changes that take place in the fertilizer are dependent upon soil conditions. This, of course, determines the residual effect of the fertilizers. In a broad sense, soils compete with the plants for the fertilizer applied. The extent to which soils compete with plants for the fertilizer applied is determined by soil conditions. Fertilizer applications should be based upon soil types as well as the economic returns that may be obtained from the crop grown.

Fertilizer and lime applications should be considered for a cropping system over a period of four to six years for greatest efficiency. Then the residual effects of fertilizers and lime can be appraised. Soil tests and soil survey reports showing the soil type (indicating the nature of the subsoil) are the best sources of information upon which to develop a fertilizer and lime program.

Each year general fertilizer suggestions for major field and horticultural crops are published by the Extension Service. These suggestions are based on field research studies and soil test summaries. It is assumed that average land management will be exercised in following these suggestions.

Fertilizer recommendations, both from soil test reports and the general recommendations that are published annually by the Extension Service, are given in terms of number of pounds per acre of N (nitrogen), P_2O_5 (phosphate) and K_2O (potash). This is followed by a suggested grade of fertilizer and the amount needed per acre to obtain the recommended amount of nitrogen, phosphate and potash. Several different grades of fertilizer may be used to obtain the desired quantity of nitrogen, phosphate and potash. In any instance, the grade or grades to select are those which furnish the desired nutrients at the lowest cost per unit of the elements. Cost of application, ease of handling and residual effects must be considered also in making the selection.

Manure: Farm manure consists of the refuse from all farm animals including poultry. Actually, manure is the unused portion of the food and water given the animals. The animal body adds nothing to the feed, it only removes a certain portion to satisy its requirements. The average daily amount and composition of animal manures is shown in Table 2. The

supply of manure on most North Carolina farms is too limited to appreciably affect the organic matter content of the soils of the farm. Therefore, if the organic content of our soils is to be maintained, it must be provided by residues from crops as well as manure.

1. Composition: The amount of nutrient elements in manure varies considerably, depending upon such factors as the kind of animal, age, kind and amount of feed consumed, amount and kind of bedding used, system and care used in storage and application. Nitrogen is found in the form of urea, undigested protein and microbial tissue. Phosphorus is found both in the organic and inorganic forms. Almost all of the potassium is water soluble.

2. Care and Handling: Greatest losses in nutrient elements from manure involve soluble nitrogen and potassium. Adequate amounts of absorbent litter will conserve a large part of the liquid portion. Conversion of the proteinaceous nitrogen into ammonia by microbial action and denitrification of nitrate nitrogen are responsible for considerable losses ot nitrogen.

3. Storage: If necessary, leave the manure in feed lots or where produced, and let animals keep compacted but be sure to add sufficient litter or bedding. In removing manure from barns or feed lots for storage, place in a heap and keep compacted, but not waterlogged.

4. Benefits: Manure adds all nutrient elements needed for plant growth that were contained in the feed and as such influences the chemical, physical, and biological properties of the soils. It adds organic matter, improves soil structure and increases soil permeability. It may help to get legumes inoculated. An application of several tons of manure per acre is needed to markedly influence crop yields.

5. Necessary Precautions: Manure can be a breeding place for flies and a source of distribution of noxious weeds, some animal diseases and parasites. Composting the manure in large heaps with the use of insecticides will do much to alleviate these problems.

Table 2.

Average Daily Production and Approximate Composition of Manures

Animal	Average daily production pounds	N	Pounds Per Ton P_2O_5	K_2O*
Horses and mules	35	12	5	10
Cattle	52	10	3	8
Sheep	2.5	21	6	20
Hogs	6	10	7	13
Chicken	0.1	24	18	9

*These values are based on fresh manure and not that which is available to plants following application to the soil.

Application of Limestone:

One of the most important problems in management of soil in North Carolina is getting farmers to use adequate amounts of lime. North Carolina soils in the virgin state are acid in reaction. Soil test summaries indicate that at least 4 million tons of limestone are needed to bring North Carolina soils up to the optimum production level with an annual application of about a million tons per year to maintain this level.

Objectives of Liming:

(1) To overcome soil acidity and the deleterious effects resulting from acid soils.

(2) To supply calcium and magnesium which are essential for plant growth.

(3) To improve the conditions for greater activity of soil microorganisms.

(4) To obtain the optimum pH range for the availability of essential elements such as phosphorus and several of the trace elements.

(5) To reduce leaching of bases like potassium and ammonium.

Practices:

The total acidity of a soil determines the amount of liming materials that must be added to overcome the acid condition. The amount and kind of clay and the per cent of organic matter in the soil greatly influences the total acidity. Therefore, different soils may have the same pH value but an entirely different total acidity and require different amounts of liming materials. Sandy soils which are low in clay and organic matter contain less total acidity than clay loams of the same pH and require less liming materials.

Although sandy soils require less lime to change the pH than finer textured soils, they must be limed more frequently. Sandy soils are likely to need limestone about once every three to five years, but clay soils probably will not need liming more than once in five to ten years.

Soil tests are the best guide to lime requirements and soils should be tested at least once every three to five years to determine the acidity level.

Types of Liming Materials that may be used:

Dolomitic limestone, calcitic limestone, hydrated lime, burned lime and basic slag.

Limestones contain the calcium and magnesium in the carbonate form and are generally recommended for overcoming soil acidity. Dolomitic limestone contains both calcium carbonate and magnesium carbonate. For

acid soils in North Carolina, both calcium and magnesium are usually deficient. Therefore, a dolomitic limestone that contains at least 15 per cent magnesium carbonate is recommended.

Calcitic limestone contains calcium carbonate but very little magnesium carbonate. It will overcome soil acidity but will not furnish the magnesium needed on at least 90 per cent of the acid soils in this state. Marl beds along the coast and crushed oyster shells are largely calcium carbonate. If marl is mixed with dolomitic limestone (45 per cent magnesium carbonate) so the mixture contains at least 15 per cent magnesium carbonate, good results can be obtained.

Hydrated lime (or water slaked lime) is calcium hydroxide and burned lime (quick lime) is calcium oxide. These materials are more effective than limestone in overcoming soil acidity (pound per pound) and are faster acting but are much more expensive. The relative rates of use in respect to limestone are given below:

Limestone [$CaMgCO_3$]	2,000 pounds per acre
Hydrated Lime [$Ca(OH)_2$]	1,500 pounds per acre
Burned Lime [CaO]	1,120 pounds per acre
Basic Slag	2,200-2,500 pounds per acre

Rate of Reaction of Liming Materials:

Liming materials react relatively slow in soils. The speed of reaction is related to the fineness of the material and the thoroughness with which it is mixed with the soil. The more acid soils will also react somewhat more rapidly than slightly acid soils. In other words, as soils approach neutrality, there is less acidity and the reaction must depend to a greater extent upon solubility of the material in water.

Hydrated and burned lime react somewhat more rapidly than limestone.

Time of Application:

Since the influence of lime will last for several years - and the reaction rate is slow - limestone should be mixed with the soil at least three months and preferably six months before it is needed on crops such as clover or alfalfa.

Methods of Application:

Lime moves but little in the soil. Although it may be broadcast on the surface of the ground, it should be thoroughly mixed with the upper six inches of soil.

Quality of Limestone:

The quality of limestone is dependent upon purity and fineness. A guide to the availability of lime in respect to size is shown below:

Particle Size	Available within 3 years, per cent
Larger than 4 mesh (1/4 inch)	0
4 to 8 mesh	10
8 to 50 mesh	40
Passing a 50 mesh screen	100

Mesh refers to the number of openings per linear inch. According to the regulations of the State Department of Agriculture, limestone sold in this state must have the following size characteristics: 100 per cent through a 10-mesh screen and 50 per cent through a 100-mesh screen. There is no regulation on purity other than the seller must show the calcium carbonate equivalent. Good limestone should have a calcium carbonate equivalent of at least 90 per cent.

Gypsum:

Gypsum is calcium sulfate and since it is a neutral salt, it does not overcome soil acidity or affect the pH of the soil. Gypsum is more soluble in water than calcium carbonate and can be used as a source of calcium and sulfur for plant growth.

The greatest use of gypsum in North Carolina is in the production of peanuts. The soils on which peanuts are produced are generally sandy and it is impossible to build the calcium level high enough for the requirements of the peanuts through the use of limestone without raising the pH so high that trace elements such as manganese become deficient. Peanuts must have a high level of calcium in the zone of pod formation to insure adequate fill. An application as a top-dressing of 400 pounds per acre of gypsum to peanuts is a general recommendation which is desirable to follow on sandy soils regardless of the soil acidity. On very acid sandy soils, limestone as well as gypsum should be used for the peanuts.

Land Preparation, Planting, Cultivation and Harvesting

Preparation: Land preparation and seedbed preparation is necessary to get good stands and yields of all crops (including forage, pasture and woodland). Different crop and different soil conditions require various kinds of preparation. Some of the factors to consider:

1. Main reasons for seedbed preparation are to get the soil in good condition for seed germination, to give the young plants a good start and to bury weed seed.

2. Moisture content of the soil should be such that it can be worked in a loose friable condition which permits packing of the soil around the seed at planting without destroying soil structure. Plowing

the land too wet puddles it or breaks down desirable soil structure. This is especially important in clayey soils, for the range of moisture content in which plowing is desirable is much narrower than for sandy soils. (This narrow moisture range is especially critical of eroded soils such as the Caroline, Craven and Lenoir groups of the Coastal Plain; Davidson group soils and eroded Mecklenburg, Iredell, White Store and Cecil groups of the Piedmont.)

3. Seedbed should be firm and well prepared but not pulverized or puddled.

4. Best methods to use depend upon soil conditions, slope of the land, erosion, climatic conditions, time of year, previous crop and crop to be planted.

5. Deep plowing. Deep plowing (deeper than eight inches with a moldboard turning plow) has not given consistent results, but in most studies to date this practice has seldom paid off in increased crop yields. However, deep plowing coupled with proper liming and fertilizing of the plowed layer may help overcome the so-called "plow pans" or "traffic pans" found just below the plow layer in soils such as the Norfolk and Marlboro.

6. Subsoiling - attempts to increase crop yields by subsoiling (defined for purpose of this discussion as pulling "chisels" through the subsoil at depths greater than 12 inches at regularly spaced intervals of about one to three feet) have not been generally successful to date in North Carolina. A few studies have shown yield increases, but a summary of experiments to date indicates that subsoiling seldom pays for the operation. However, a combination of subsoiling and/or deep plowing plus lime and fertilizer added to the subsoil may be

profitable on North Carolina soils with brittle and compact subsoils.

Deep plowing and subsoiling should be considered only in conjunction with application of adequate amounts of lime and fertilizers and then only when there is good reason to believe that yield increases will be obtained.

7. Land preparation is not a substitute for other management practices, but is a part of them.

Planting: Several basic principles must be recognized and followed in order to get satisfactory stands of crops. These are:

1. Selection of high quality seed of adapted variety - select high quality seed which is true to type, of high germination and free from weed seeds and diseases. <u>Certified</u> <u>seed</u> has been inspected for these qualities.

2. Preplanting treatment of seed when necessary, such as scarification and chemical treatments. The seed coat of hard seeds must be scratched (scarification) or partially removed to improve germination. Chemical treatment of some varieties of seed is necessary to control seed-borne diseases such as smut. These treatments also help protect sprouts from fungi and other pests in the soil.

3. Depth of planting - the larger the seed the deeper it may be planted down to the maximum depth at which it will readily emerge. (This optimum planting depth is greater on sandy soils than on loamy and clayey soils.) Large seed (cotton, corn, beans) are planted deeper than small seed (clover, grasses, lespedezas) because they have stronger sprouts and contain more stored food. Planting seed at greatest depth at which it will emerge places it in a zone of more favorable moisture. However, soil temperature decreases with depth which may be important. A uniform depth

of planting is more readily obtained in a firm well-prepared seedbed.

4. Rate of planting - planting rates should vary with water control in the soil, soil fertility (use of fertilizers) and crop quality desired. For example, corn for silage is planted at higher rates than corn for grain. Droughty, infertile soils will not support as thick stands as fertile drought resistant soils.

5. How the planting is done - best planting places the seed at uniform depth in the soil and distributes the seed evenly at the desired rate.

a. Broadcast plantings ordinarily are not as satisfactory as drilling. Broadcasting followed by dragging with a harrow or other tool mixes the seed in the soil but many seeds are covered too deep or are left on the surface and are lost.

b. Drilling - the grain drill, especially when fitted with a grass seed attachment, gives control of depth and rate of seeding as well as application of fertilizer. If a grass seed attachment is not available for small seed, the regular grain hopper can be used. If it cannot be adjusted for the small seeds, they can be mixed with cotton seed meal or sawdust.

Cultivation: Points to consider in tilling the soil after the crop has been planted are:

1. Control of weeds is main purpose for crop cultivation. Other less important purposes are to break crusted soil surfaces to increase water infiltration, to improve the soil conditions temporarily for beneficial microbes, and to improve soil conditions for best development of underground plant parts such as peanuts and potatoes.

Studies have shown little or no difference in crop yields where weeds were controlled by cutting them at ground level with no other cultivation as contrasted to cultivation several times by standard methods. Unnecessary and late cultivations actually reduce yields. In general, cultivate a crop no more than is necessary to control weeds. (See section on weed control.)

2. Time of cultivation - highest yields and best weed control are ordinarily obtained while the plants are young, or even before emergence. Late cultivation prunes the root system of the crops and reduces yields.

3. Type of cultivation - shallow, nearly level cultivation is best for crops except tobacco and potatoes. Ridge cultivation is generally used for these crops, as well as for other crops on those soils where better drainage in the root zone is needed.

Time of planting and harvesting: Important points to consider in time of planting and harvesting are:

1. Effect of time of planting on crop sequence - tobacco, cotton, corn and peanuts are planted too early to fit small grains just ahead of them in a crop sequence. Soybean, milo and millet planting can be delayed until after harvest of small grain.

2. Effect of time of harvesting on crop sequences - tobacco and silage corn are ordinarily harvested in time for small grain planting. Soybeans and seed lespedeza harvesting dates are ordinarily too late for fall small grain seedings, except possibly wheat.

3. Stage of maturity - best quality and yields are obtained by harvesting at proper stage of maturity. Differences in flexibility of time of harvesting need to be kept in mind in planning. For example, tobacco and certain perishable truck crops must be harvested within a few

hours after maturity for best quality, but corn is much less exacting in time of harvesting.

4. Planting and harvesting dates - best average dates for planting and harvesting have been established by research and farmer experience for the various regions of the state. These dates (with allowances for the particular season) ordinarily give the highest yields but may not be practical for circumstances of a given farm. The most practical solution is to work out a compromise plan for planting and harvesting that gives the highest return for the farm as a whole.

Ranges in time of planting and harvesting for major North Carolina field crops are listed in table 3.

Table 3.

Planting and harvesting dates for major North Carolina field crops.

Crop	Average optimum planting date	Harvest dates
Flue-cured tobacco	May 15 - Oxford April 25 - Whiteville; transplanting period 10-15 days, 10% loss in value per week delay afterward.	About 65 days after transplanting, within about 2 days of individual leaf ripening.
Cotton	April 15 - Coastal Plain May 1 - Piedmont: optimum planting period of 2 weeks.	Within 10-14 days after maturity; loss of $5-10 per bale per 2 weeks delay.
Corn	April - 1st half of May for eastern 2/3 of N. C.	(Late maturing hybrids tend to outproduce early hybrids)
Peanuts	April 25 - Whiteville May 10 - Rocky Mount May 15 - Virginia line; optimum planting period about 2 weeks.	60 days after peak flowering or slightly over 5 months after planting - when maximum number of mature pods on vines - a 10-20 day period.
Soybeans	May 5 - June 30; earlier gives loss 3-6 bushels per acre.	Within 30 days after maturity, though Lee variety will stand for several months.

Wheat	Piedmont: not earlier than October 10 because of Hessian fly, optimum for 2-3 weeks after this date, 20% yield reduction for delay to November 15. Coastal Plain: not earlier than October 25, optimum for 2-3 weeks after, with 15% loss for delay to November 25.	Fairly flexible harvest period, but shattering and milling quality losses for delay after maturity.
Oats	Piedmont: October 1 and 3 weeks after, delay to Nov. 15 causes 50-60% yield reduction. Coastal Plain: October 10 and 3 weeks after, delay to November 15 causes 30% yield losses.	Within 2 weeks after maturity.
Barley	(Same as for oats except for about 30% yield reduction for November 15 seeding in Piedmont.)	
Alfalfa	August 10 - Laurel Springs Septmmber 10 - Raleigh September 25 - Rocky Mount Earlier planting hazardous due to slow germination, soil heaving, and cold injury. Spring planting not recommended, with possible exception of some mountain areas.	One-tenth bloom or when new buds emerge - optimum period lasts about 7 days.
Ladino clover - grass mix -	(Optimum planting dates same as alfalfa.)	More leeway in harvesting time if spring growth cut for silage.
Milo	Early May to mid-June - when soil is warm.	After optimum moisture content (about 13%) is reached; flexible because grain does not ripen all at once.

Pest Control

Weed Control

Weeds can seriously reduce crop yields in North Carolina by competing with crops for water, robbing crops of nutrient elements, shading them from sunlight and actually attacking and living upon crops parasitically.

Nearly all kinds of weeds can be controlled in a good management program by cultural practices and through use of chemicals.

Current suggestions on controlling weeds are given in the following tables.

Insects

Insect pests can be controlled with varying degrees of success by modifying cultural practices, such as the time of planting and harvesting, cultivation, crop sequence, handling of crop residues, adjacent crops or other plants (especially weeds), fertilization and selection of varieties. Where cultural controls are not adequate, effective insecticides, such as DDT and Chlordane, are available.

In order to make the most effective use of cultural practices in insect control, knowledge of the insect's life history and habits is essential. Modification of a specific farm practice ordinarily is useful for only one kind of insect. Some of the basic principles pertaining to insect control are listed below:

1. Certain kinds of insects feed on specific crops and cannot thrive on most other crops.

2. Insects cannot move extensively.

3. Insects have relatively long life cycles. Their rate of reproduction is relatively slow.

4. Several years may be required for a certain kind of insect to build up to maximum destructiveness.

5. Crops can be changed when the insect is in a nonmigratory stage.

6. Adult insects prefer certain conditions for egg deposition.

TABLE 4. CHEMICAL WEED CONTROL TREATMENTS IN COMMON USAGE

Crop or Plants	Weeds	Time to Spray	Chemicals to Use and Rate Per Acre	Precautions and Remarks
Corn and Sorghum	Crabgrass, cocklebur, morning glory, pigweed, lambsquarter, ragweed, etc.	Pre-emergence: Simazin; 2,4-D. Spray surface of soil after planting but prior to emergence.	Simazin: 2 lb./A (Active) 2,4-D (Acid equiv.). Amine recommended except on sandy soil where low-volatile esters suggested. 1 to 2 lb./A. for corn. 1 lb./A for milo or sorghum.	2,4-D: Plant corn at least 1 in. deep in a well-fertilized, properly prepared seedbed. Poor weed control may result under dry conditions. Injury to corn stand may occur if heavy rains follow chemical application before corn is established. Do not cultivate or disturb soil until corn is 12-14 in. tall or until weed control becomes necessary. Not suggested for extremely light sandy soils.
	(a) Cockleburs, pigweed, ragweed, lambsquarters, morning glory (b) Smartweed, partridge pea.	Post emergence: Spray overall before corn is 6 in. tall or spray with "dropped nozzles" from 6-36 in. tall.	Amine salt of 2,4-D (a) ½ lb./A acid equiv. (b) ½ to ¾ lb./A acid equiv.	2,4-D: Apply to growing weeds while they are small. Do not cultivate for about 10 days. Hybrids are usually resistant but inbreds can sometimes be injured. Injury from too much 2,4-D: brittleness, lodging, curved stalks, and abnormal brace roots.
Small Grain (Wheat, Oats and Barley)	(a) Winter annuals, such as ragged robin, mustard, vetch, blessed thistle, wild radish. (b) Corn cockle and dock.	Spray when grain is 4-8 inches tall or when tillered but not jointing.	Amine salt of 2,4-D (a) ½ lb./A acid equiv. (b) ¾ lb./A acid equiv.	Spraying small grain too young or after jointing can result in reduced yields and uneven ripening. Seeding of lespedeza etc. must be delayed two weeks following first good rain after treatment.
Lawns	Dandelion, plantain, and other broadleaved annuals.	Spray well-established lawn grasses while weeds are young and growing rapidly. March treatment will help control crabgrass. Repeat treatment 4 wks. later.	Amine salt of 2,4-D ½ to 1 lb./A depending upon weeds.	Danger to flowers and ornamentals from nozzle "fog" and drainage water from a treated area. Covering desirable plants with tarpaulin, paper, or old sheets can relieve nozzle "fog" problem. Rapidly growing clover may be injured by 2,4-D.
Woody plants along fence rows and ditch banks	Honeysuckle, sweet gum, wild cherry, poison ivy, blackberry, sourwood, etc.	Spray when plants are in full foliage. May 15 to frost.	Use 1 lb. each 2,4-D and 2,4,5-T/A. Follow manufacturer's directions.	Nozzle "fog" and fumes can cause injury to susceptible plants. Repeat treatments when new foliage develops. Proper rates kill plants in 3 weeks in warm weather. Rapid top kill reduces root kill.
Seedling alfalfa	Chickweed, henbit, vetch, mustard, ragged robin, blessed thistle.	Spray when alfalfa is in 5-6 leaf stage (5 to 6 in. tall) and dormant.	Apply water-soluble DNBP (Dow "Premerge" or "Sinox PE") at 1 to 2 lbs. in 30 or more gallons of water.	Spray when weeds are as small as possible. Apply when temperatures are 60° F. or more and no rain is expected for 6 to 12 hours.
Alfalfa—established dormant	Ragged robin, chickweed, henbit, shepherds purse, blessed thistle.	Spray dormant alfalfa late fall, winter or early spring when weeds are small and growing rapidly.	Water-soluble Dinitro (DNBP)—1½ to 3 lbs. acid equiv. Apply enough spray to wet the plants.	Spray when temperatures are above 60° F. and no rain is expected for 6 to 12 hours. May require second treatment.
Ladino Clover orchardgrass or fescue pastures	Curled dock	Spray when weeds are 4-8" tall, before heading.	2,4-D amine or ester-½ to 1 lb. acid equiv.	Ladino may be stunted and growth retarded 3-6 weeks. Growth of orchard and fescue grasses may show increased vigor. Plan for supplemental feed.
Perennial grasses—tall fescue, orchard grass, coastal Bermuda grass	Chickweed, mustard, radish, cocklebur, vetch and other susceptible weeds.	Spray when weeds are small, particularly important with chickweed.	2.4-D, amine—¾ to 1 lb. acid equiv.	Do not spray this crop in the seedling stages or just prior to heading.

EXTENSION PUBLICATIONS ON WEED CONTROL

1. Chemicals for Weed Control--Extension Circular No. 378.
2. Nutgrass (Nutsedge) Control--Extension Folder No. 103.
3. Small Grain, Chemical Weed Control--Extension Folder 105, Revised.
4. Cautions with 2,4-D, 2,4,5-T, MCP in Weed Control--Extension Folder No. 107.
5. Chemical Weed Control in Corn--Extension Folder No. 148.
6. Bermuda Grass Control--Extension Folder 114.
7. Some Weedy Plants of N. C.--Extension Circular 390.
8. Poison Ivy, Poison Oak and Poison Sumac--Extension Folder No. 144.
9. A Farm Weed Sprayer--Extension Circular 403.
10. 1956 Weed Control in Cotton--Extension Folder, No Number.
11. So You Have Witchweed--Extension Folder No. 152.

TABLE 4a.

CHEMICAL CONTROL METHODS FOR SPECIFIC PROBLEM WEEDS

Cultural Methods are usually suggested where Acreage involved is large

Weed	Time to Apply	Chemical, Rate Per Acre and Method of Application	Precautions and Remarks
Bermuda Grass	Apply dalapon to the foliage in May or early June. Apply sodium TCA and sodium chlorate to the soil following a thorough disking early in the growing season.	Dalapon. For spot treatment use 20 lbs. of dalapon in 100 gal. of water as a wetting spray (1 lb. per 5 gal.). Repeat as needed after 6 to 8 weeks. For broadcast treatment apply 40 lbs. per acre in 40 to 50 gal. of water. Use spot follow-up treatment in 6 to 8 weeks. Sodium TCA (Sodium Trichloroacetate). Apply 75 to 100 lbs. per acre in 40 to 60 gal. of water. Sodium Chlorate. Use 1½ lbs. active ingredient per 100 square feet as dry crystals.	Dalapon sterilizes the soil for 3 to 4 weeks after application. Rains hasten detoxification. As soon as grass is killed practice shallow cultivation until crop is planted. Soils treated with Sodium TCA will be sterile from 30 days on sandy soils to 90 days on clay soils. Sodium chlorate sterilizes soil for 6 to 12 months.
Johnson Grass	Same as for Bermuda Grass.	Dalapon. Same as for Bermuda Grass except treat when foliage is less than 12 inches tall. Sodium TCA. Apply 100-125 lbs. per acre in 40 to 60 gal. of water. Sodium Chlorate. Same as for Bermuda Grass.	Same as for Bermuda Grass.
Quack-grass	Apply dalapon to foliage in early spring or early fall. Sodium TCA and sodium chlorate same as for Bermuda Grass.	Dalapon. Same as for Bermuda Grass except use 20 lbs. per acre for broadcast treatment. Sodium TCA. Apply 60 to 75 lbs. per acre in 40 to 60 gal. of water. Sodium Chlorate. Same as for Bermuda Grass.	Same as for Bermuda Grass.
Nutsedge "Nutgrass"	Following a thorough disking early in growing season. When using 2,4-D, apply when weeds are small.	Sodium Chlorate. Use 1½ lbs. active ingredient per 100 square ft. as dry crystals. See "Precautions and Remarks" under Bermuda grass. 2,4-D. Use ¾ lbs. (any form) at 3 to 4 week intervals.	Corn crop can be produced while using 2,4-D. Apply pre-emergence rate. Follow 3 to 4 weeks later with rate suggested and repeat as noted. Rate suggested can be used following tobacco harvest.
Poison Ivy and Poison Oak	Amitrol—Apply after leaves are fully developed but at least 2 weeks before killing frost. 2,4-D—apply in late spring or early summer when plants are growing rapidly.	Amitrol. Use 4 lbs. of amino triazole active ingredient per 100 gal. of water as a wetting spray. Repeat in 6 to 8 weeks if needed. 2,4-D. Use 2 to 3 lbs. active ingredient per 100 gal. of water. Repeat in 6 to 8 weeks if needed.	Apply only to plant material to be killed. Avoid drift.
Cattails	Apply before flowering stem appears.	Dalapon. Apply as described for Bermuda Grass.	

This offers an opportunity for control by alteration of management practices.

Sowing seed or setting transplants when soil temperature and moisture are optimum helps to control insects. Numerous examples can be cited which show that insect damage is increased where soil moisture levels are either below or above the optimum for the plant or where soil temperatures are below optimum.

In many cases, the date of planting can be adjusted to reduce insect damage. Examples are (1) delayed planting of winter wheat until the advent of the Hessian fly-free period and (2) early planting of cucumber and cantaloupe to avoid pickleworm damage.

Early harvest of forage crops may reduce insect damage. This applies to the meadow spittle bug and pea aphids on alfalfa.

Cultivation practices can be useful in controlling certain kinds of insects. Examples are (1) deep hilling and clean cultivation to control the potato tuber worm, (2) plowing as soon as possible after harvest to help control cucumber beetles, and (3) clean cultivation of cotton to help control the boll weevil by providing conditions whereby heat and sunlight increase the mortality of larvae in fallen squares.

Effective control of some insects, especially those whose larvae live in the soil and feed on roots, can be obtained by suitable cropping systems. Many insect pests tend to build up where crops, subject to their attack, are grown year after year. Mexican bean beetles, cabbage worms and corn rootworms are examples. Most wireworms, except tobacco wireworms, depend on continuous cover for egg laying. Therefore, the frequent use of nonrow crops are likely to favor wireworm infestations. Tobacco wireworms appear to be most troublesome when tobacco follows oats

and weeds. Southern corn rootworm damage to peanuts apparently is increased when peanuts are grown after small grain and lespedeza. The bollworm is favored when cotton is grown following legumes.

Legume cover crops in orchards tend to build up sucking bug populations. These insects migrate to the fruit, causing corky areas in peaches and apples.

Corn borer populations can be reduced by plowing under coarse stemmed weeds and corn stalks or by feeding the stalks to livestock before spring.

Destruction of tobacco stalks and suckers followed by fall plowing may reduce the winter survival of the hornworm. However, the usefulness of these practices is still uncertain because the natural enemies of the hornworm also may be destroyed.

Nearby crops or wild plants (weeds, thickets) often serve as hosts for insect pests which move to the specific crop and damage it unless controlled. Examples are aphids moving into tobacco plant beds from nearby collards and mustard, green peach aphid moving to tobacco from wild mustard, flea bettles moving from wild plants into tobacco and vegetable fields, and spider mites moving to cotton from wild broadleaf plants. Early fall and spring cleaning of fence rows and ditch banks is important in helping control these pests.

On the other hand, wild shrubs and thickets around tobacco fields may be helpful by providing favorable sites for tobacco hornworm predators. Soybeans adjacent to tobacco may attract the natural enemies of the hornworm, thereby reducing damage to tobacco.

Proper fertilization makes crops able to withstand insect attack better even though more attractive to insects.

Certain insects may be controlled by the choice of variety to be grown. Varieties may be resistant or tolerant to a given insect or escape injury because of plant characteristics or date of maturity. Some examples are early maturing cotton varieties to escape late season boll weevil damage, resistance of NC-2 peanuts to pod and kernel damage, resistance of long season corn hybrids to rice weevil and storage insect pests, and resistance of certain alfalfa lines to alfalfa weevil.

DDT and Chlordane are effective in insect control, but their use has had certain limitations. Certain kinds of insects have become resistant to insecticides. An example is cabbage worm resistance to DDT. Insecticides may give off-flavors to crop plants or may kill off natural enemies of certain pests thus permitting them to become more numerous.

It seems that insecticides will continue to be useful but that the cultural control methods discussed in the previous paragraphs will become of greater importance in the future than they are at present.

Diseases

Our crop plants are subject to a wide variety of infectious plant diseases. North Carolina is especially vulnerable because of the diversity of its crops, some of which have been cultivated intensively for more than 100 years, its long growing season and its warm, humid climate.

The numerous methods of control of infectious plant diseases can be classified under four broad principles, as follows:

1. Exclusion - the pathogen is presumed not to be present and steps are taken to prevent or restrict entry. Use of certified seed and planting stock, seed disinfection, quarantine, inspection, etc.

2. Eradication - the pathogen is presumed to be present and steps are taken to destroy it or to reduce its population to nonhazardous levels. Seed disinfection, soil fumigation, rogueing, sanitary measures, destruction of infested weed hosts, cropping systems, destruction of crop residues that harbor pathogenic organisms, etc.

3. Protection - the pathogen is presumed to be present and steps are taken to place a protective barrier between the pathogen and the vulnerable host plants or practices are undertaken which are designed to prevent or reduce infection and/or disease severity. Spray and dust fungicides, seed protectants, cultural practices which promote vigorous growth and disease tolerance or which take advantage of circumstances that are favorable to the host but not the pathogen (good soil and air drainage, proper spacing, proper nutrition, timely seeding, depth of seeding, cultivation, irrigation, etc.).

4. Resistance - breeding disease resistant or tolerant varieties.

Because there are usually several destructive diseases of most of our crops (seven or eight on tobacco) the problem of control for each crop is complex and in most cases requires a well-rounded program involving a combination of control practices rather than reliance upon only one or two practices. Moreover, the development of such a program depends upon knowledge of the kinds of diseases andthe life history and behavior of each pathogen. Here are some important factors to consider:

1. Nature of pathogen - fungus, bacterium, nematode, virus, etc. Proper diagnosis is important. (Plant Disease Clinic.)

2. Source of inoculum - soil, crop refuse, seed, etc.

3. Means of dissemination - air, water, insects, soil, etc.

4. Plant parts affected - roots, above ground organs.

5. Rate of buildup - method, frequency, and rate of reproduction.

6. Persistence of inoculum - how long will the pathogen survive in the absence of the host.

7. Host range - the kinds and varieties of susceptible plants attacked, host specificity.

8. Environmental requirements - temperature, moisture, etc.

Although it is difficult and sometimes unwise to deal in generalities, we can set forth some categories and patterns of behavior of certain plant disease causing organisms which might be helpful in management considerations.

A vast number of plant diseases occur on the above ground parts of plants and include the rusts, downy mildews, powdery mildews, anthracnoses, various leaf spots, twig and blossom blights, fruit spots, etc. In general, these diseases are characterized by localized infections, relatively short disease cycles, and rapid spread and build up under favorable conditions. Most of these pathogens are quite specific in their host and environmental requirements. The factors of aerial environment fluctuate widely and rapidly in response to changes in weather conditions. Hence, the occurrence of epidemics depends upon a sequence of events leading to a situation characterized by the following: (1) Extensive areas of susceptible host plants in a vulnerable or unprotected condition, (2) a high inoculum level of the pathogen and (3) environmental conditions favorable to disease development. Any break that can be brought about in the chain of events may thus interrupt or delay the onset of disease and reduce its intensity. Frequently, infested seed or refuse of the previous crop serves as the initial source of inoculum to start the process. Hence, the use of non-infested or

disinfested seed, the destruction of infested crop residues and the use of crop rotation are of much value in control.

The diseases caused by soil-borne organisms have patterns of development that differ considerably from those that involve the above-ground plant parts. The soil environment does not fluctuate as widely or rapidly as the aerial environment but is much more complex. Soil-borne organisms are generally of three types, as follows:

1. Those that are well adjusted to the soil environment and can live as saprophytes in competition with other soil organisms. These include certain seed decay, seedling damping-off and root rotting organisms. They may persist indefinitely and are nonspecific in their host requirements. Crop rotations generally are not effective as control measures. Chemical seed protectants and soil treatments are usually helpful and cultural practices that promote rapid seed germination, seedling emergence and vigorous growth are beneficial.

2. Organisms that persist indefinitely in the soil generally because of the existence of long lived, resistant spores or resting bodies. These pathogens are more specific in their host requirements than those discussed above. Because of their ability to persist for long periods in the absence of the host, short crop rotations are of little value, unless used in conjunction with resistant or tolerant varieties. Long rotations may be effective but are seldom practical. Chemical soil treatments are effective in some cases. Examples of this group of diseases are the vascular wilts, black root rot of tobacco and other crops, club root of crucifers, blackshank of tobacco and root rot of pea.

3. Nonpersistent root inhabiting organisms. Most of the parasitic nematodes fall into this category. They are obligate parasites that

ordinarily do not survive more than 18 months in the absence of a suitable host. Although many are quite specific in their host requirements, certain species have wide host ranges. Some species are comprised of numerous strains that differ in their food requirements. Crop rotations, cultural practices and chemical treatments designed to reduce nematode populations to noninjurious levels are effective in control.

Nematode diseases are of major importance in North Carolina because of the large numbers of destructive kinds that occur and the wide variety of crops attacked. There are more than ten important genera, that cause more than 40 million dollars loss each year. Some of the root parasitic forms, such as the root knot nematodes, meadow nematodes and stunt nematodes are widely distributed and have wide host ranges. Others, such as the alfalfa stem nematode and the soybean cyst nematode are quite host specific and are restricted in distribution.

MANAGEMENT OF LAND NOT IN CROPS (INFREQUENTLY CULTIVATED)

It is recognized that a discussion on land management problems in North Carolina must include all of the land area in each of the major land uses. Four major land uses are recognized. They include: (a) crop land (b) woodland (c) range land (d) pasture land. This publication is largely confined to the details of land management on cultivated crop land; however, a brief statement summarizing the principles of management on woodland, range and pasture land is included. It is recognized that pasture, range and woodland are all crops of a type, but differ from regular cultivated crops in management requirements. It is also recognized that there may be dual uses of land with a primary and secondary use. Land use may change from time to time, and when this change occurs, management requirements will change to fit the use and

treatment needs. To treat properly each of these major land uses in detail, a separate publication for each major land use is desirable.

Planning the Pasture Needs:* Good pasture land management begins with planning the pasture according to the land capability. The foundation of a sound pasture program is perennial grasses used with adapted legumes. The perennial grasses used should be grasses such as fescue or orchard grass, as well as a summer grass like Common Bermuda, Coastal Bermuda, Dallis or Bahiagrass. Most perennial grazing programs will need to be supplemented with hay, silage or annual grazing crops.

Principles of Establishment: To help in the successful establishment of a pasture, practices listed above for row and grain crops should be used as well as the following:

1. Begin preparing seed bed four to six weeks before seeding time.

2. Inoculate alfalfa, Ladino clover, red clover and crimson clover seed just prior to seeding.

3. Spread seed uniformly and cover lightly, and immediately. Most seeded grasses and legumes should be covered 1/4 to 1/2 inches deep. A cultipacker is one of the best tools for uniform but light coverage. Cross seeding helps insure more uniform stands.

4. Sod crops which can become established in the fall will produce normally the first year. However, some crops must be spring seeded; e.g., Sericea and annual lespedeza, Dallis grass and summer annuals.

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* Forage Guide, N. C. Bulletin.

5. Use irrigation where available to get stands up and started.

6. Allow crops to become well established before using.

Maintenance Principles:

1. Maintain proper fertility level - top-dress annually.

2. Fertilize just ahead of best growing season.

3. Avoid overgrazing and undergrazing. Grazing closer than three inches on most species greatly reduces forage production. Undergrazing reduces feeding value and quite often encourages diseases and insects.

4. Graze rotationally.

5. Mow to conserve surplus growth for hay or silage to control certain weeds, and to help keep plants at their most succulent and nutritious stage.

6. Chemicals should be used to control certain other weeds, such as dock.

7. Rotate and renovate every four to ten years or as needed.

8. Insects and diseases of forages are usually unpredictable. However, the plants should be observed carefully and frequently to detect outbreaks. Each insect and disease has specific control measures and must be identified before proper recommendations can be given.

Rotation of pasture sods with cultivated crops (a) permits excellent yields of cultivated crops, (b) helps to control pasture weeds, diseases and insects, (c) helps in the reestablishment of pasture sods, (d) extends the benefits of grass over a larger acreage.

10. Pasture sods should be renovated or reestablished in contour strips on steep or eroded land.

Use and Management of Range Lands

<u>Range Management Principles</u>: On range land, high forage production, soil, water and plant conservation are obtained primarily by improvement of the native vegetation. This is accomplished by managing the grazing to encourage and increase the best native forage plants.

Leaf development, root growth, flower stalk formation, seed production, forage regrowth and food storage in the roots are essential for these natural growth sequences, if maximum forage yield and peak animal production are to be obtained.

Livestock graze selectively, constantly seeking out the more palatable and nutritious plants. If grazing use is not carefully regulated, the better plants are eventually eliminated and the less desirable or second choice plants increase. If grazing pressure is continued, even the second choice plants can be thinned out or eliminated and undesirable weeds or invaders take their place.

<u>If only about half the yearly volume of grass produced is grazed</u>, damage which occurs to the better plants is minimized and ranges can improve. The unharvested portion of the forage crop remaining influences further growth as follows:

1. Allow roots to reach deep moisture; overgrazed grass cannot reach deep moisture because not enough green shoots are left to provide the food needed for good root growth.

2. Allows the better grasses to crowd out weeds, which means that ranges in a low state of productivity will improve

3. Enables plants to store food for quick and vigorous growth after droughts and in the spring.

4. Provides a greater feed reserve for the dry spells that other-

wise might force sale of livestock at a loss.

Sound range management requires that grazing use be adjusted from season to season in accordance with forage production. Range livestock operations should provide for reserve pastures or other feeds for use during droughts or other periods when forage production is curtailed.

On pond-switchcane range, a decrease in forage volume occurs as timber stands develop. On well-managed pine woodland areas, control of undesirable woody plants, proper thinning and harvest cutting encourage the highest forage production consistent with timber production. Managed grazing of pond pine woodlands in turn reduces fire hazard, contributes to hardwood control by use of sprouts, and is sometimes helpful in years of pine seed production and getting seed in contact with the mineral soil.

<u>Management practices which improve range vegetation</u> cost little to use and are needed on all range land regardless of what other practices are used. Such practices are proper range use, deferred grazing and rotation-deferred grazing.

<u>Range improvement practices</u> make it easier to control livestock on the range and to practice better management. These practices include range seeding, water development, fencing, trail or road building, salting and control of undesirable plants.

Farmers control the lion's share. Lack of good management on these lands constitutes the biggest forestry problem in North Carolina today.

Workable procedures which will encourage and enable farm owners to institute, maintain and benefit from good forestry practices on their holdings are urgently needed.

Management: Timber stands throughout the state are predominantly second growth. They are comprised of a variety of tree species, occurring in both pure stands and admixtures of several to many species.

Woodland management principles:

Two primary objectives are involved in woodland management:

(1) Protection of the resource from its four principal enemies -- the destructive agents - fire, harmful grazing, diseases and insects.

(2) Regulation, through proper cutting and other silvicultural practices, of the forest or woodland growing stock as to quantity, distribution of age and size classes, and rotations in order to provide a sustained yield of timber and other wood products.

Protection: Fire damages forests and woodlands in several ways, killing many outright, especially young trees and retarding the growth of others. Uncontrolled fire causes a loss of nutrient elements, and in the case of organic soils, actually destroys them. Trees are scarred permitting insects and diseases to gain entrance. This results in further damage. The value of wood products may be reduced in half by fire damage.

Firebreaks should be constructed and maintained to help prevent woodland fires. Land owners should cooperate with the State Division of Forestry and their neighbors to prevent woodland fires.

Damage from harmful grazing, while much less spectacular, may be just as severe as that caused by fire. Livestock causes mechanical injury to exposed tree roots, permitting diseases and insects to enter. Also, they eat the young trees. Woodlands should be separated from pastures with good fencing.

It is estimated that diseases and insects together destroy more timber annually than fire. Besides killing some trees, growth is retarded

on any trees attacked by either of these destructive agents.

Reforestation: In North Carolina forest tree species should be planted for wood production, to control erosion, to serve as windbreaks and for Christmas trees. Land in the following conditions should be planted: (1) cut-over woodlands and existing stands of trees which are so run-down that they are not reseeding, or are reseeding too slowly; (2) land that has been made unsuitable for crop production by sheet or gully erosion: (3) rocky or hilly land; (4) land that is restocking to worthless kinds of trees; and (5) odd corners of land suitable for cultivated crops or pasture, but which are too small or too inaccessible for these uses.

Desirable cutting practices: The proper cutting practices for forests and woodlands in the state include stand improvement, thinning and harvest cutting. Depending upon the forest type, age, size class and stand condition, these practices may be employed singularly or in combination in the same forest or woodland.

Stand improvement measures consist of cleanings or weedings, liberation or release cuttings and improvement cuttings.

Thinnings are cuttings made in immature stands for the purpose of increasing the rate of growth or improving the form of trees that remain and increasing the total production of the stand. Trees selected to leave should be the best in the stand. Follow the principal of cutting the worst trees first.

Harvest cutting differs form stand improvement cuttings and thinnings in that the objective is to remove crop trees, thereby cashing in on the stand, rather than to improve the remaining trees. The manner in which it is done, however will determine whether the forest or woodland

APPENDIX

Part 1. Soil Management Groups for North Carolina

North Carolina soils have been placed in the groups shown in the following tables according to similarity in certain chemical, mineralogical and physical characteristics. Characteristics selected for the grouping are those important in soil management and use which are ordinarily not changed or modified by management practices. That is, they are rather permanent in nature. [1/]

Names of soils composing each of the soil management groups are listed in the first table. Though the soils of a given group are similar in their more permanent characteristics, they differ from each other in one or more ways and are recognized as distinct soil series.

Explanation of the columns of the summary tables:

1. Soils: Soil series composing each group are listed, following a general description of the group. The soil names which are underlined and head each of the group lists are used as the group names.

2. Mineralogy: Kinds of crystalline clay minerals in the soils are indicated by letters for the various clay minerals. These letters are arranged in order of their abundance of the mineral in the respective soils; the first letter listed stands for the most abundant clay mineral

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1/ Technical Bulletin 115 of North Carolina Agricultural Experimental Station describes color and texture (content of clay, sand and silt) of each of these soils and the materials from which they have formed. This bulletin also contains a map showing in a general way where the soils are located in the state.

in the soil group. For example, if K is listed first kaolinite is the most common clay mineral in soils of that group. Letter symbols and descriptions of the kinds of clay minerals are as follows:

K = kaolinite, most common clay mineral in North Carolina soils; a two-layer silicate of low exchange capacity.

V = vermiculite or vermiculite-like, second most common in North Carolina soils; a three-layer silicate of high exchange capacity and high potash fixing power unless decreased by effect of aluminum between clay crystal plates - which seems to be a factor in most North Carolina soils.

i = illite, a three-layer mica-like silicate of medium exchange capacity and which holds potassium in slowly available form between the crystal plates.

C = chlorite, a three-layer silicate of medium to high exchange capacity containing very tightly held magnesium (or aluminum?) between the crystal plates.

M = montmorillionite, a three-layer silicate with high exchange capacity and ability to absorb water between crystal plates, thus causing swelling (and shrinking when water dries out) of soils containing this mineral.

Gi = gibbsite, crystalline aluminum hydroxide; no exchange capacity.

Note: In some soils certain of these clay minerals occur together in highly interlayered (interstratified) form - this is indicated by a slanting line between their letter symbols, as I/V.

3. Cation exchange capacity: Measure of ability of soil to attract and hold certain kinds (but not all) of nutrients, or cations, (mainly

calcium, magnesium and potassium) in a form readily available to plants. Thus, it is a partial plant food storage capacity. Permanent exchange capacity refers to that part of this ability to hold certain nutrient elements which is always present in soils and is due to the structure and composition of the clay minerals present in the soil. The clay minerals have a varying excess of negative electric charge which is counterbalanced by a sort of electromagnetic attraction of the positively charged calcium, magnesium, or potassium ions (or aluminum in very acid or "sour" soils.) The permanent exchange capacity is the type most important in soil fertility. The pH sensitive exchange capacity refers to that portion of total cation exchange capacity which increases in amount as the soil is made less acid - as in liming. Soil organic matter is apparently composed mostly of pH sensitive exchange capacity, thus its capacity to attract and hold nutrient ions increases as the pH rises (soil made more alkaline or sweet and less acid.) On the other hand, soils composed mostly of montmorillonite clay minerals possess large amounts of permanent exchange capacity, and relatively little pH sensitive exchange capacity.

This cation exchange, or "storage", capacity is indicated in relative amounts in the tables. This capacity can be approximately measured in the laboratory and is expressed in chemical terms designated "milliequivalents per 100 grams of soil", abbreviated me/100 g. Relative levels are shown in the tables and are related to numerical values measured in the laboratory in the following manner:

For permanent cation exchange capacity:			For pH sensitive cation exchange capacity:		
Low (L)	=	0-3 me/100 g	Low (L)	=	0-5 me/100 g
Medium (M)	=	3-10 me/100 g	Medium (M)	=	5-15 me/100 g
High (H)	=	10-20 me/100 g	High (H)	=	15+ me/100 g
Very High (VH)	=	20+ me/100 g			

4. Exchangeable or "readily available" aluminum: An indication of the amount of aluminum presumably held by the exchange capacity forces described in the previous section. The importance of this characteristic is that this aluminum is the underlying cause of acidity or sourness in most soils and if present in large enough amounts is actually poisonous to plant roots. A level of medium (M) or higher as indicated in the table is likely to cause extreme acidity and reduction of plant growth. Most of this aluminum is held by the permanent type of exchange capacity though some is present in soils of high organic matter content. Relative levels of this form of aluminum are indicated in the tables and are related to actual amounts measured in the lab in the following way:

Very Low (VL)	=	less than 1 me/100 g
Low (L)	=	1-2 me/100 g
Medium (M)	=	2-5 me/100 g
High (H)	=	5-10 me/100 g
Very High (VH)	=	greater than 10 me/100 g

5. Available or exchangeable base status: Refers to the relative amounts of bases, or available calcium, magnesium and potassium, held by the previously described exchange capacity of the subsoil. The levels given in the tables are estimates of the relative amounts of these nutrient elements or bases which are held by the subsoil in a form

readily available to plants. The relationships between the relative levels of "base status" given in the table and the amounts as measured in the laboratory expressed in chemical terms are:

Very low (VL)	=	less than 1 me/100 g
Low (L)	=	1-2 me/100 g
Medium (M)	=	2-5 me/100 g
High (H)	=	5-10 me/100 g
Very High (VH)	=	greater than 10 me/100 g

6. Available water storage capacity: Means the ability to store water that is available to plants in the pores of the soil. This storage capacity is important in estimating the ability of a soil to supply water during dry periods and in estimating the amount of supplement irrigation to apply.

Table 5.

Soils Comprising Soil Management Groups

(The underlined soil name heading each group is the group name)

1. Coastal Plain:

Norfolk	Goldsboro	Lynchburg	Rains	Portsmouth
Cahaba	Nixonton	Barclay	Fallsington	Pocomoke
Kalmia	Woodstown	Dragston	Myatt	Okenee
Orangeburg		Stono	Pasquotank	Weeksville
Ruston				

Marlboro	Gilead	Duplin	Dunbar	Bladen
Caroline	Vaucluse	Craven	Bertie	Coxville
Faceville		Flint	Lenoir	Elkton
Magnolia		Keyport	Warne	Leaf
			Wahee	Othello

Kenansville
Rumford

Lakeland	Klej	Plummer	Rutlege	Bayboro
Blanton	Barth		Elwell	Byars
Eustis	Scranton			Cape Fear
Galestown				
Huckabee				
Independence				

Leon	St. Johns	Hyde	Muck
Immokalee			

11. Piedmont:

Cecil	Durham	Davidson	Georgeville
Appling	Alamance	Hiwassee	Herndon
Bradley	Chesterfield	Tirzah	
Lloyd			
Madison			
Masada			
Wadesboro			
Wickham			

Vance	Mecklenburg	Iredell	Helena
Cataula	Efland	Enon	Orange

Granville	White Store	Altavista	State
Mayodan	Creedmoor		Starr

Colfax	Worsham	Congaree
		Bermudian

Chewacia	Wehadkee
Rowland	Bowmansville

Louisburg	Wilkes
Goldston	
Louisa	

111. Mountains and Foothills:

Hayesville	Rabun	Porters
Balfour	Clifton	
Fannin	Dyke	
Masada	Hiwassee	
Wickham		
Fletcher		

State	Talladega
Tate	Chandler
Tusquitee	

Ashe	Halewood	Congaree	Chewacia	Wehadkee
Ramsey	Surry	Transylvania		
	Watauga			
	Perkinsville			

Table 6.

Summary of soil properties by soil groups

1. Coastal Plain, page 1

1. SOILS	2. MINERALOGY	CHEMICAL CHARACTERISTICS: 3. Cation exch. (partial plant food storage capacity of topsoils: permanent	3. ... of subsoils: permanent	3. ... of subsoils: pH sensitive (pH sens. varies w/mgmt.)	4. Exchangeable (readily available) aluminum in: topsoils	4. ... subsoils	5. Available (exch.) base status, subsoil	PHYSICAL CHARACTERISTICS: 6. Available/storage water capacity, inches: to 12"	6. ... to 36"
Norfolk group description: Soils with good natural drainage, thick red to yellowish brown sandy clay loam subsoils (B horizons) and grayish to light brown sandy loam-fine sandy loam topsoils (A horizons). "Thick surface" phases of loamy sand are common and are lower in plant food and water storage capacity than indicated in this table.									
Norfolk Cahaba Kalmia Orangeburg Ruston	K = V except upper Coastal Plain where K dom.	L	M	L	VL	L	L	1"	4"-
Goldsboro group description: Soils with fair natural drainage (high water occasionally and slightly wet) and yellow-brown friable sandy clay loam, sandy loam or silt loam subsoils (B horizons) and gray brown thick fine sand loam or silt loam topsoils (A horizons). Thick surface phases fairly common in Goldsboro soils, these are lower in water and plant food storage capacity than indicated in this table.									
Goldsboro Nixonton Woodstown	K = V, minor 1 & Gi; K dom. upper Coast. Pl.	L	M	L	VL-L	L	L	1"	4"-
Lynchburg group description: Soils with somewhat poor natural drainage (wet part of year unless drained) with streaked gray, brown, yellow sandy clay loam, silt loam or sandy loam.									
Lynchburg Barclay Dragston Stono	K = V, minor 1 & Gi; K dom. in upper C. P.	L	M	L	L	L	VL-L	1"	4"+
Rains group description: Soils with poor natural drainage (wet much of year unless artifical drainage) with gray (may be yellow streaked) friable; sandy clay loam, silt loam or sandy loam subsoils (B horizon) and gray fine sandy loam, sandy loan, silt loam topsoils (A horizon).									
Rains Fallsington Myatt Pasquotank	K = V; minor M, 1, Gi	M	M	L	L-M	M	L	1"	4.5

Table 6.

Summary of soil properties by soil groups

1. Coastal Plain, page 2

1. SOILS	2. MINERALOGY (type of clay)	CHEMICAL CHARACTERISTICS: 3. Cation exch. (partial plant food storage capacity) of topsoils: permanent	3. of subsoils: permanent	3. of subsoils: pH sensitive	4. Exchangeable (readily available aluminum in: topsoils	4. subsoils	5. Available (exch.) base status, subsoil	PHYSICAL CHARACTERISTICS: 6. water Available/storage capacity, inches: to 12"	6. to 36"
		(pH sens. varies w/mgmt.)							
Marlboro group description: Soils with good natural drainage and red to yellow brown firm sandy clay or silty clay to clay subsoils and thin brown to gray-brown sandy or fine sandy loam topsoils (A horizons):									
Marlboro Caroline Faceville Magnolia	V = K (toKK dom. in upper C.P.), minor 1, Gi	L	M	L	VL	L	L-M	1+	4+
Gilead group description: Soils of Sandhills with good natural drainage, of compact yellow-red to yellow brown sandy clay-sandy clay loam subsoils (B horizons) and gray or gray sandy loam topsoils (A horizons)									
Gilead Vaucluse	(no data)	L	M	L	VL	L?	VL		
Duplin group description: Soils with medium natural drainage (slightly wet); very firm yellow brown or brown & yellow streaked sandy clay, clay, or clay loam subsoils (B horizons) and thin gray or gray brown fine sandy loam or silt loam topsoils (A horizons)									
Duplin Craven Flint Keyport	V = K (upper C.P., K dom.), minor V/1, 1, Gi, M	L	M	L	VL	L	M-L	1.5+	5

Table 6.

Summary of soil properties by soil groups

1. Coastal Plain, page 3

1. SOILS	2. MINERALOGY (type of clay)	CHEMICAL CHARACTERISTICS 3. Cation exch. (partial plant food storage capacity of topsoils			4. Exchangeable (readily available aluminum in:		5. Available (exch.) base STatus subsoil	PHYSICAL CHARACTERISTICS 6. Available/storage water capacity, inches	
		of topsoils	of subsoils						
		permanent	permanent	pH sensitive	topsoils	subsoils		to 12"	to 36"
		(pH sens. varies w/mgmt.)					*		
Portsmouth group description: Soils with very poor natural drainage (high waterable and wet much of the time unless artifically drained), with friable gray sandy clay loam, sandy loam, or silt loam subsoils and black or dark gray loam, sandy loam or silt loam topsoils.									
Portsmouth Pocomoke Okenee Weeksville	V dom. to V = K, some 1 and M	M	M	L	M	M-H	L-VL	1.5	4.5-5
Kenansville group description: Soils with good natural drainage and yellow brown to yellow red sandy loam (to light sandy clay loam) subsoils (B horizons) and grayish to light brown sandy loam to loamy sand topsoils (A horizons); ordinarily underlain by sand. Thick surface phases fairly common; ordinarily loamy sand of lower water and plant food storage capacity than indicated in this table.									
Kenansville Rumford	V/C = K	L	L-M	L			L-VL	1	3.5
Dunbar group description: Soils with somewhat poor natural drainage (high watertable and/or wet part of year); streaked yellow, gray and brown firm sandy to silty clay or clay subsoils (B horizons and gray sandy loam to silt loam topsoils (A horizons)									
Dunbar Bertie Lenoir Warne Wahee	K = V = V/1, minor 1, Gi, M	M-L	M	L	VL	L	M	1.5	5

Table 6.

Summary of soil properties by soil groups

1. Coastal Plain, page 4

1. SOILS	2. MINERALOGY (type of clay)	CHEMICAL CHARACTERISTICS: 3. Cation exch. (partial plant food storage capacity: of topsoils			4. Exchangeable (readily available) aluminum in:		5. Available (exch.) base status, subsoil	PHYSICAL CHARACTERISTICS: 6. Available/water storage capactiy, inches	
		permanent	of subsoils: permanent	of subsoils: pH sensitive	topsoils:	subsoils:		to 12"	to 36"
		(pH sens. varies w/mgmt.)							
Bladen group description: Soils with poor natural drainage (wet with high watertable much of the time unless artificially drained); gray and yellow streaked sandy clay or clay subsoils and dark gray fine sandy loam to silt loam or silty clay loam topsoils									
Bladen Coxville Elkton Leaf Othello	M = V to M dom.; minor 1, K	M	M-H	L	L	M-H	H-M (M-L for Coxville?)	1.5	5
Bayboro group description: Soils with very poor natural drainage (wet most of the time with high watertable unless artificially drained), gray firm clay, silty clay or clay loam subsoils and gray to dark gray or black thick humus-rich topsoils									
Bayboro Byars Cape Fear	V = M, some K; 1, C, V/1	M	M-H	L	L	M-H	M-H	1.5-2	4.5-5
Hyde group description: Soils with very poor natural drainage (wet much of the time with high watertable, not easy to drain artificially) and very thick black to dark gray humus-rich and often mucky topsoils and gray sandy clay, silty clay or silty clay loam subsoils.									
Hyde	(no data)	M	M	L					
Leon group description: Soils with somewhat poor natural drainage (wet part of the time, high watertable several weeks of year unless artificially drained) with brownish-black so-called "organic hard pan" in subsoil below gray sand topsoils (Note: St. Johns soils are similar but have poor natural drainage).									
Leon Immokalee	(no data)	(no data)							

Table 6.

Summary of soil properties by soil groups

1. Coastal Plain, page 5

1. SOILS	2. MINERALOGY (type of clay)	3. CHEMICAL CHARACTERISTICS: Cation exch. (partial plant food storage capacity) of topsoils: permanent	of subsoils: permanent	of subsoils: pH sensitive	4. Exchangeable (readily available) aluminum in: topsoils:	subsoils:	5. Available (excn.) base status, subsoil	6. PHYSICAL CHARACTERISTICS: Available/water storage Capacity, inches: to 12"	to 36"
				(pH sens. varies w/mgmt.)					
Muck group description: Black organic soils with very poor natural drainage; designated Shallow Muck if less than 42 inches over mineral soil (this is more common than deep muck); organic matter greater than 30 per cent with no plant remains visible; Peat has rawer, fresher organic matter but chemical tests may be needed to distinguish from Muck.									
Muck	(no data)	L	L (to M if mineral soil)	Very High	Variable: L-M to none	Variable: (L-M to none)	VL (ordinarily)		
Lakeland group description: Sandy soils with good natural drainage - yellow red to yellow brown and yellow lapse loamy sand or sand subsoils and brown to gray loamy sand or sand topsoils									
Lakeland									
Blanton	K = V, some 1	L	L	L	VL	VL	VL	.5+	2.5
Eustis									
Galestown									
Huckabee									
Independence									
Klej group description: Sandy soils with somewhat poor to medium natural drainage (wet, with high watertable part of year), gray, brown and yellow streaked loose loamy sand or sand subsoils; gray, dark gray or gray brown sand or loamy sand topsoils (A horizon)									
Klej									
Barth	V dom. to V = K,	L	L	L	VL	L	VL	0.5	2+
Scranton	minor 1 and M								
Plummer group description: Sandy soils with poor natural drainage (wet and high watertable much of the time unless artificially drained) gray and yellow loose loamy sand or sand subsoils and dark gray to black sand topsoils									
Plummer	V dom to V = K, some 1, M	L	L	L	L	L	VL	0.5	2
Rutlege group description: Sandy soils with very poor natural drainage (wet and ponded most of the time unless artificially drained) with thick black sand or loamy sand topsoils which are sometimes mucky or peaty; gray loose sand or loamy sand subsoils									
Rutlege	V dom to V = K,								
Elwell	some 1, M	L	L	L	VL-	L	VL	0.5	2

Table 6.

Summary of soil properties by soil groups

II. Piedmont, page 1

1. SOILS	2. MINERALOGY (type of clay)	CHEMICAL CHARACTERISTICS 3. Cation exch. (partial plant food storage capacity of topsoils	of subsoils		4. Exchangeable (readily available) aluminum in:		5. Available (exch.) base status subsoil	PHYSICAL CHARACTERISTICS 6. Available/water storage capacity, inches	
		permanent	permanent	pH sensitive	topsoils:	subsoils:		to 12"	to 36"
		(pH sens. varies w/mgmt.)							
Cecil group description: Soils with gray brown or light brown sandy loam topsoils (A horizons) and red, yellow red, or yellow brown streaked with red, clay to sandy clay subsoils (B horizons) formed from light colored rocks									
Cecil									
Appling	K, V, small amts. of Gi	L-M	L	L	VL	L-M	L	1-1-1/2	5
Bradley									
Lloyd									
Madison									
Masada									
Wadesboro									
Wickham									
Georgeville group description: Soils with gray brown smooth silt loam topsoils (A horizons) and red, yellow red to reddish yellow firm silty clay or clay subsoils (B horizons) formed from "Carolina Slates"									
Georgeville									
Herndon	K, some 1, V	M-L	L-M	M	VL-L	L	L	1-1/2"+	5+
Davidson group description: Soils with reddish brown to brown loam, clay loam or silt loam topsoils (A horizons) and dark red to red clay subsoils (B horizons)									
Davidson	K & H dom., some								
Hiwassee	V/1, some V in	L-M	L	M	VL	VL	M-L	1-12"-2	5-1/2
Tirzah	Hiwassee, Tirzah								
Durham group description: Yellow soils with gray to light yellow thick sandy loam to silt loam topsoils (A horizons) and friable sandy clay loam to silty clay loam subsoils (Bhorizons)									
Durham	K, V; or V								
Alamance	greater than K	L	L	L	VL	L	L	1	4-5
Chesterfield									

Table 6.

Summary of soil properties by soil groups

II. Piedmont, page 2

		CHEMICAL CHARACTERISTICS						PHYSICAL CHARACTERISTICS	
1. SOILS	2. MINERALOGY (type of clay)	3. Cation exch. (partial plant food Storage capacity of topsoils	of subsoils		4. Exchangeable (readily available) aluminum in:		5. Available (exch.) base status, subsoil	6. Available/water storage capacity, inches	
		permanent	permanent	pH sensitive (pH sens. varies w/mgmt.)	topsoils:	subsoils:		to 12"	to 36"
Granville group description: Soils with gray brown or light yellow brown sandy loam (some silt loam in Mayodan) topsoils over yellow brown or yellow and red friable sandy clay to sticky clay subsoils, over weathered Triassic sandstones									
Granville									
Mayodan	K = V, some V/C	L	L	L	L	M	L	1-1.5	4-5
White Store group description: Soils with gray or yellowish brown sandy loam topsoils over yellow, red and gray very sticky heavy clay over weathered Triassic rocks (Creedmoor has thicker topsoil and is deeper to heavy clay)									
White Store									
Creedmoor	K = V = M	L	H	L-M	L	H	L	1-1/5	2-5
Louisburg group description: Soils with grayish brown to brown thin sandy loam or loamy sand to silt loam topsoils shallow (ordinarily less than 18 inches) over hard rock or soft partly weathered rock (Louisburg over gneisses, Goldston over "Carolina Slates", Louisa over mica schists). (Subsoils very thin or absent).									
Louisburg									
Goldston	(no data)	L	L	M	X	X	LM (goldston)	<1	2
Louisa									
Wilkes group description: Soils with grayish brown sandy loam to loam topsoils over yellow and brown thin subsoils over mixed light colored and dark colored rocks. (Subsoils thin)									
Wilkes	K, some V, little M	L	M	M	VL	VL-L	M-H	<1	2-2.5
State group description: Soils with brown to reddish brown fine sandy loam to loam and to silt loam topsoils over yellowish brown to reddish brown subsoils over stream depostis of "second bottoms" (State) or slopewash along footslopes (Starr)									
State									
Starr	(no data)	M-L	M	L	X	VL-L	L-M	1-1/2	4-5
Vance group description: Soils with thin gray or pale brown sandy loam topsoils underlain byyellow or red very sticky heavy clay subsoils, often containing streaks of soil material formed from "basic" rocks; over weathered granite rocks									
Vance									
Cataula	K	L	L-M	L	L	L	M		

Table 6.

Summary of soil properties by soil groups

II. Piedmont, page 3

		CHEMICAL CHARACTERISTICS						PHYSICAL CHARACTERISTICS	
1. SOILS	2. MINERALOGY (type of clay)	3. Cation exch. (partial plant food storage capacity of topsoils		of subsoils	4. Exchangeable (readily available) aluminum in:		5. Available (exch.) base status, subsoil	6. Available/water storage capacity, inches	
		permanent	permanent	pH sensitive	topsoils:	subsoils:		to 12"	to 36"
		(pH sens. varies w/mgmt.)							
Mecklenburg group description: Soils with brown or yellow brown loam or clay loam topsoils over yellow-red sticky clay subsoils, over dark colored "basic rocks (Efland in "slate belt")									
Mecklenburg Efland	(no data)	M-H	M-H	L	VL	L-VL	M		
		(pH sens. varies w/depth)							
Iredell group description: Soils with loam to sandy loam topsoils over yellow sticky clay subsoils, 2 to 3 feet thick over partly weathered dark colored rocks.									
Iredell Enon	M, V, some K	L	H-M	L	VL	VL or none	H		
Helena group description: Soils with gray coarse sandy loam topsoils and yellow streaked with gray sticky clay subsoils over weathered granite (Helena or clayey "Slates" (Orange), may contain small areas of soil formed from dark colored rocks.									
Helena Orange	K & V with some with M	L-VL	M	L	L	M	L (M to H in areas formed) from dark colored rocks)		

Colfax group description: Soils with gray sandy laom (silt loam in places) topsoils over yellow sandy clay loam to sandy clay subsoils often streaked with "rust" or gray due to somewhat poor natural drainage; formed on footslopes, along drainageways or "upland saddles" (Worsham soils have formed from similar material but have poor natural drainage as shown by gray subsoils.)
(No data available for these soils.)

For information on Congaree, Chewacia, Wehadkee and associated soils of the floodplains (first bottoms), see descriptions in the section of mountain soils.

Table 6.

Summary of soil properties by soil groups

III. Mountains and foothills, page 1

1. SOILS	2. MINERALOGY (type of clay)	CHEMICAL CHARACTERISTICS 3. Cation exch. (partial plant food storage capacity of topsoils			4. Exchangeable (readily available) aluminum in:		5. Available (exch.) base status subsoil	PHYSICAL CHARACTERISTICS 6. Available/water storage capacity, inches	
		of topsoils: permanent	of subsoils: permanent	of subsoils: pH sensitive	topsoils:	subsoils:		to 12"	to 36"
		(pH sens. varies w/mgmt.)							
Hayesville group description: Soils with yellowish brown sandy loam, loam or silt loam topsoils over yellowish red, and red clay loam or silty clay loam subsoils to depths of 2 to 3 feet over soft weathered, or hard, light-colored rocks - some highly mica-rich,									
Hayesville									
Blafour	K, V, some 1/V	L	L	L-M	VL	L	L	1.5	3.5
Fannin									
Masada									
Wickham									
Fletcher									
Rabun group description: Soils with reddish brown to brown loam-clay topsoils and red to brown clay loam or clay subsoils to depths of 2-3 feet or more over soft weathered or hard dark colored (basic) rocks.									
Rabun									
Clifton	K; equal V &1, some M	M	M-L	M	VL	VL-L	M	1.5	5.5
Dyke									
Hiwassee									
Porters group description: Soils with grayish brown to brown loam topsoils over brown clay loam subsoils, 2-1/2-3-1/2 feet deep over hard or soft weathered rocks containing some dark minerals.									
Porters	V, K, 1	M	M	L	VL	L	L-M	1.8	5
Halewood group dexcription: Soils with grayish brown loam fine sandy loam topsoils underlain by yellowish brown clay loam-silty clay topsoils, 2-1/2-3 feet deep over light colored rocks, variably hard or soft.									
Halewood									
Perkinsville									
Surry	K, V, 1	M-L	M	L	VL-L	M-L	L-M	1.7	3
Watauga									

Table 6.

Summary of soil properties by soil groups

III. Mountains and foothills, page 2

1. SOILS	2. MINERALOGY (type of clay)	CHEMICAL CHARACTERISTICS 3. Cation exch. (partial plant food storage capacity of topsoils: permanent	3. of subsoils: permanent	3. of subsoils: pH sensitive	4. Exchangeable (readily available) aluminum in: topsoils:	4. subsoils:	5. Available (exch.) base status subsoil	PHYSICAL CHARACTERISTICS 6. Available/water storage capacity, inches: to 12"	6. to 36"
				(pH sens. varies w/mgmt.)					
Ashe group description: Soils with grayish brown to brown sandy loam-loam topsoils and yellowish brown loam subsoils 1-2 feet thick over light colored granitic rocks or sandstones and quartzites.									
Ashe									
Ramsey	K, V	L	L	L	M-L	M-H	L-VL		
Talladega group description: Soils with grayish brown loam topsoils and yellowish red to yellow highly micaceous clay loam-loam subsoils, 1-1/2-3 feet thick over variably hard and soft weathered mica schists.									
Talladega									
Chandler	(no data)	L	L-M	L	L	M	L-M		
State group description: Soils with grayish brown to brown loam sandy loam topsoils over brown, yellowish brown subsoils developed in high bottomlands or slopewash deposits at foot of slopes.									
State									
Tate	(no data)	L	L-M	L	VL-L	L	L-M	1.5	4
Tusquitee									
Congaree group description: Brown to yellowish brown or very dark brown (Transylvania loamy, well-drained soils of the bottomlands (floodplains). Chewacla soils have somewhat poor natural drainage and mottled yellow and gray subsoils; Wehadkee soils have poor natural drainage thus have dark gray topsoils and gray subsoils. These soils are otherwise similar in properties to Congaree soils.									
Congaree	(no data)	M	M	L	?	?	L	1-1.3	3-4

Part II. Relationship between groups of soils with similar "permanent" basic properties (Table 6.) and Land Capability Units

Soil groups of similar chemical, mineralogical and physical properties are shown in the left side of the pairs of columns below. The underlined soil names are the group names and the indented soil names below the underscored names indicate which soils belong to each group (some groups are composed of only one soil). The Land Capability Units (as established and defined by the Soil Conservation Service) to which these soils have been assigned are shown in the right hand side of the paired columns. Some soil series are placed in a number of Capability Units because of variations in conditions of slope, degree of erosion, surface texture and other characteristics which influence conservation measures. The Capability Unit grouping emphasizes interpretations of properties that are important in soil and water conservation as related to land management.

Table 7. Soil Groups and Capability Units

MOUNTAINS AND FOOTHILLS

SOILS	CAP. UNITS
Hayesville* Balfour Fannin Fletcher	IIe-2-M, IIIe-1-M, IVe-1-M, VIe-1-M, VIIe-M
Masada Wickham	I-M, IIe-1-M, IIIe-1-M, IVe-1M, VIe-1-M, VIIe-M
Rabun* Clifton	IIe-2-M, IIIe-1-M, IVe-1-M, VIe-1-M, VIIe-M
Dyke Hiwassee	I-M, IIe-1-M, IIIe-1-M IVe-1-M, VIe-1-M, VIIe -M
Porters* Halewood* Perkinsville Watauga Edneyville Surry	IIe-2-M, IIIe-1-M, IVe-1-M, VIe-1-M, VIIe-M
Ashe* Ramsey Talladega* Chandler	IIIe-2-M, IV-2-M, VIe-2-M, VIIe-M
State Tate* Tusquitee*	I-M, IIe-1-M, IIIe-1-M, IVe-1-M, VIe-1-M, VIIe -M
Congaree Transylvania	IIw-1-M
Chewacla	IIIw-1-M

SOILS	CAP. UNIT
Altavista Augusta	IIw-2-M
Warne	IIIw-2-M
Wehadkee	IVw-1-M
Toxaway	IIIw-1-M

*The stony phases of the soils in these groups are in the Cap. Units indicated below: IIIe-2-M, IVe-2-M, VIe-2-M, VIIe-M

PIEDMONT

SOILS	CAP. UNIT
Cecil Appling Bradley Madison Wadesboro Masada Wickham Lloyd Durham Chesterfield Alamance Granville Mayodan	I-1-P, IIe-1-P, IIIe-1eP, IVe-1-P VIe-1-P, VIIe-1-P (Sandy loams, fine sandy loams, coarse sandy loams)
Cecil group Durham group Granville gr. Davidson Hiwassee Tirzah Georgeville Herndon State Starr	I-2-P, IIe-2-P, IIIe-2-P, IVe-2-P, VIe-1-P, VIIe-1-P (loams, silt loams, very fine sandy loams, clay loams) (severely eroded phases of these soils in VIIe-2-P
Vance Cataula Mecklenburg Efland Iredell Enon Helena Orange White Store Creedmoor	IIe-3-P, IIe-3-P, IVe-3-P, VIe-1-P, VIIe-1-P (severely eroded phases of these soils in VIIe-2-P

SOILS	CAP. UNIT
Congaree Bermudian	IIw-1-P
Colfax Augusta	IIw-2-P
Altavista	IIw-2-P IIe-3-P IIIe-3-P
Chewacla Rowland	IIIw-1-P
Worsham Warne	IIIw-2-P
Wehadkee Bowmansville	IVw-2-P
Louisburg Goldston Louisa Wilkes	IIIe-4-P IVe-3-P VIe-1-P VIIe-1-P

(Continued)

COASTAL PLAIN

SOILS	CAP. UNITS	SOILS	CAP. UNITS
Norfolk Cahaba Kalmia Orangeburg Ruston Marlboro Faceville Magnolia Matapeake	I-C, IIe-1-C, IIIe-1-C, Ive-1-C VIe-1-C, VIIe-1-C	Dunbar	IIw-2-C
		Bertie Lenoir Wahee Warne	IIIw-4-C
		Bladen Coxville Elkton	IIIw-2-C (silt loams and silty clay loams in IVw-2-C
Caroline Gilead Vaucluse	IIe-3-C, IIIe-2-C, IVe-1-C, VIe-1-C, VIIe-1-c	Othello	IIIw-2-C
		Leaf	IVw-2-C
		Kenansville Rumford	IIs-C, IIIs-C IVs-C, VIIs-C
Duplin	IIw-1-C, IIe-2-C, IIIe-1-C	Lakeland Eustis Galestown Huckabee Independence Blanton	IIIs-C, IIIs-C, VIIs-C
Craven Flint Keyport	IIw-1-C, IIe-3-C, IIIe-2-C, Ive-1-C VIe-1-C, VIIe-1-C		
Goldston Nixonton Woodstown Altavista	IIw-1-C, IIe-2-C, IIIe-1-C	Klej Barth Scranton	IIIw-1-C IIIs-C IVs-C
Lynchburg Barclay Dragston Stono Augusta	IIw-2-C	Plummer	IIIw-1-C, IVw-1-C
		Rutlege Elwell	IIIw-1-C, IIIw-3-C, (fine sand IVw-1-C)
		Bayboro	IIIw-2-C
Rains Fallsington Pasquotank	IIw-3-C	Byars Cape Fear	IVw-2-C
Myatt Portsmouth Pocomoke Okenee	IIIw-3-C	Leon Immokalee St. Johns	IVw-1-C
Weeksville	IIw-3-C (Thick surface phases)	Hyde	IIIw-3-C
		Muck	Ivw-3-C
		Norfolk group Goldsboro Gilead	IIs-C IIIs-C IVs-C, VIIs-C

Part III. Definitions of Land Management Terms

Adaptation: degree to which plants are suited to grow under specified environmental conditions.

Capability: inherent characteristics of a soil which determine its ability to be used or developed in order to sustain yields over a period of years.

Conservation farm plan: a plan for the use of soil, water and plant resources on a farm in line with the needs of the enterprise and skills and desires of the farmer in a manner which will maintain the real capital value of the land.

Fertility: nutrient status of the soil and its ability to supply or transmit nutrients to plants.

Land: soil plus site characteristics and location.

Land Capability Class: a class of land in the capability classification scheme which designates the magnitude of hazards and limitations in using land.

Land Capability Subclass: a division of the land capability class which designates the major kind of hazard or limitation involved in using the land.

Land Capability Unit: a unit of land which is ordinarily an aggregation of soil conditions into management groups which give appreximately the same degree of response to treatment.

Management, farm: appraisal of production possibilities, selection of those consistent with the goals of the manager, and execution of a plan of action to accomplish these goals.

Management, land: appraisal of alternative treatments relative to the use of land for specific purposes, selection of practices to be used, and direction of the use of desired practices.

Productivity: a measure of capacity of land to yield relative to specified inputs.

Soil depletion or decline: changes in physical and/or chemical characteristics that make a soil less productive, but the soil may be feasibly restored to production.

Soil deterioration: destruction of physical and/or chemical characteristics of a soil beyond feasible level of replacement, resulting in permanent reduction in productivity.

Suitability: degree to which a soil is fitted to grow a given crop under specified environmental conditions.

Soil Conservation: management of soil in such a manner as to maintain its real capital value.

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